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A FAMOUS RUSSIAN ENCYCLOPAEDIA OF ASTRONAUTICS—2

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SUMMARY

The first article in this series on Professor N. A. Rynin's *Mezhplanetnye Soobshcheniya* (see *J.B.I.S.*, 1954, **13**, 193) reviewed the first four books of this nine-volume work. The present article is concerned with Books V and VI and the first part of Book VII; the remaining sections will be dealt with in the concluding part of this series.

V. *"Theory of Reactive Motion."*

In addition to being one of the more important of the nine volumes from the technical point of view, *"Theory of Reactive Motion"* is distinguished from the other nine books in being a paper reprinted from the Proceedings of the Leningrad Institute of Road Communication Engineers (*Sbornik Instituta Leningradskii Inzhenerov Putei Soobshcheniya*, 1929, 101). Appended to the paper is an English summary, which is reproduced here without grammatical correction:

> *"The object of transportation is to carry a given load at a given distance as quickly and with as great economy as possible.*
>
> *Problems of land, water and air transportation have already undergone sufficient investigation. We possess excellent theories concerning the motion of locomotives, steamships, gas locomotives, motor-ships, automobiles, airplanes, airships and other mechanical motors.*
>
> *Of late, however, a new kind of motor has been invented, i.e. the reactive motor. Although the rocket, whose motion is based on the principle of reaction, has been known for a long time, the principle itself has only quite lately been applied to problems of transport, and the theory of reactive motion has only just begun to be elaborated.*
>
> *The present paper describes of what elements the theory consists, and gives its main principles, as applied to the motion of the reactive motor, both within and without the precincts of the atmosphere. It further deals with the action of gravitation and of atmospheric resistance. Various kinds of fuel are examined, as well as the conditions of various accelerations of motion. Finally, the theoretic computations made by various foreign scientists concerning the flight of a rocket in cosmic space are examined."*

The first two sections of the paper constitute a brief introduction to the idea of rocket-propelled vehicles; the third, although headed *"Equation of Motion*

of a Rocket," is concerned with the momentum equation for vertical ascent. This is given in the form

$$c(1-k).dm = (M-m).dv + [R + g(M-m)].\ dt$$

M being the initial mass of the rocket, m the mass lost after time t, c the exhaust velocity and v the speed of the rocket at time t. The term R represents the air resistance, whilst k is a constant representing the ratio of the mass of the structure to the mass of structure plus propellants. This is *not* the mass ratio in any of the senses in which that term is usually employed (initial mass of rocket/ "allburnt" mass, mass of fuel/initial mass of rocket, etc.), since Rynin assumes that the structure falls from the rocket at the same rate as the fuel is burnt, i.e., that the burning of $(1-k).dm$ units of fuel is accompanied by the loss of $k{\cdot}dm$ units of structure. Certain observations can immediately be made concerning the various terms in this equation. Thus it is obvious that M cannot be extremely large, and hence it is desirable that m should be a minimum. At high velocities, R is large in comparison with the gravitational term. The exhaust velocity c should be as large as possible, but in manned vessels must not exceed a certain limit.

Certain of the variables in this equation are now considered in greater detail, beginning with the gravitational term. Working from the inverse square law, it is shown that the work necessary to remove 1 kg. to infinity is $6{\cdot}37 \times 10^6$ kg.m. and that the "neutral zone" between Earth and Moon lies at a distance of 345,963 km. from the Earth's centre. Formulae for circular velocity and parabolic (escape) velocity ($= \sqrt{2} \times$ circular velocity) are deduced and the values for most of the major planets and a few asteroids are tabulated. The next step is obviously to deal with the Sun's gravitational action and the use of elliptical paths in travelling to the other planets.

The resistance of the atmosphere is dealt with in more detail. Formulae developed by various workers (Oberth, Malloch, Hohmann, and Krantz) are compared; they vary in emphasis, but relate the resistance to such quantities as the cross-section, shape and orientation of the rocket, its speed, the density of the air, a friction factor, the nature of the wave at the nose of the rocket, etc. Several empirical formulae obtained from data on the flight of artillery projectiles are also given. To-day, however, the information given must be considered as largely irrelevant to astronautics: air resistance will not be a major factor during the ascent of a spaceship. It will be a matter of supreme importance when returning to Earth and landing, but the data necessary for the solution of the problems involved in this aspect will only be obtained as a product of present and future research with high-altitude rockets and rocket aircraft.

Next follows a consideration of the fuel; this section provides interesting evidence of the development that has taken place over the past twenty-five years. In 1929, wood, coal, gunpowder, dynamite and nitro-cellulose could still find a place in the list of possible propellants; hydrogen peroxide was not mentioned. However, the list also included some of to-day's favourites (such as hydrogen plus oxygen), whilst a footnote refers to the combustion of lithium, boron and aluminium. There are exhaust velocities for the combustion in oxygen of carbon, benzene, heptane, pentane, methane, hydrogen and atomic

hydrogen. The values given are not related to conditions in practical motors, nor are they derived from the adiabatic flow equation (although this is quoted), but are theoretical values obtained simply by equating calculated heat of combustion with kinetic energy: $m.Q = \frac{1}{2}m.V^2$. Rynin criticizes a patent application taken out by A. A. Andreev on February 18, 1921, for a rocket to enable a man to ascend to a height of 22 km. in about 7 minutes, the fuels being liquid methane and liquid oxygen. According to Rynin's calculations, the ascent would be made in 7/13 minutes and he considers that the acceleration would be dangerous for the man. I have not bothered to check the arithmetic; there is a more obvious criticism to make if Rynin's description of the patent is correct. The man was not supposed to be inside the rocket or even sitting on it as if it were a "flying bedstead"; it was strapped to his back! This is dangerous, whatever the acceleration!

Having thus led the subject round to the question of danger to potential astronauts, the physiological effects of acceleration are next discussed. This section does not enter deeply into medical aspects, but rather is concerned with the magnitude of the acceleration experienced by persons shot from cannons (in circuses), flying in an aeroplane travelling in a curved path, travelling in a lift, on a roundabout (incidentally, the Russian word for this is karusel', corresponding to the American nomenclature, as theatregoers will recognise), etc. Free fall conditions are dealt with in two short paragraphs.

The second half of this book outlines mathematical theories developed by other workers. First of all come those of Rynin's countryman Tsiolkovskii, in four sections: (*i*) vertical flight in an environment without gravitation and atmosphere, (*ii*) vertical flight in an environment with gravitation, (*iii*) oblique flight in an environment with gravitation, and (*iv*) upward flight with gravitation and an atmosphere.

Of the four sets of conditions, the first is obviously the simplest, but it is not of any great interest to us at the moment, really being relevant only to interstellar travel. It is, however, a case which is frequently chosen, to explain the elementary principles of rocket flight. The equation derived is usually written nowadays as

$$V = c.\ln R$$

and relates the final velocity of the rocket, V, with the exhaust velocity c and the mass ratio R. Rynin calls this Tsiolkovskii's First Equation; his notation is slightly different. From this equation it follows that during burning of the propellants the velocity of the rocket is continually increasing, but that the rate of increase (or acceleration) is continually decreasing. Tsiolkovskii's Second Equation is an expression giving the ratio between the kinetic energy of the rocket and that of the fuel; Tsiolkovskii termed this ratio the *utilization* (u_1). In the symbols used above, this equation becomes

$$u_1 = \frac{[\ln R]^2}{R-1}$$

Using these equations, Rynin has tabulated the conditions existing at various

stages of the flight of rockets with exhaust velocities of 4,000 and 5,000 metres/sec. Returning to algebraical analysis, it is shown that u_1 will be greatest when the speed of the rocket equals the exhaust velocity. Also if a rocket travels in a straight line from one point to another by using its motor to accelerate from rest to maximum velocity and then to decelerate to rest, the mass ratio for the whole journey is the square of that for the period of acceleration.

When gravitation is taken into account, the mass ratio R for the gravitationless case is replaced by

$$R^{\frac{b}{b-g}}$$

b being the acceleration (constant) of the rocket. This relation between the two mass ratios constitutes Tsiolkovskii's third equation. Conditions obtained at various stages of the flight are again tabulated, for $b = 4g$ and $10g$. In all this, the acceleration due to gravity is taken as constant throughout the flight.

The third aspect of Tsiolkovskii's work considered here—oblique flight in a gravitational field—refers to a rocket with its thrust acting at an angle γ to the direction of gravitation (the "vertical"). In this case the relative acceleration of the rocket is $b_1 = \sqrt{b^2 + g^2 - 2bg.\cos\gamma}$. For vertical flight this reduces to $b_1 = b - g$; for horizontal flight to $b_1 = b^2 - g^2$. Hence the ratio between the work done in oblique flight and that done in vertical flight is

$$u' = \frac{b^2 + g^2 - 2bg.\cos\gamma}{(b-g)^2}$$

and by writing $b = ng$ (the acceleration of the rocket) this becomes:

$$u' = \frac{n^2 + 1 - 2n\cos\gamma}{(n-1)^2}$$

For horizontal flight this reduces to $u' = \dfrac{n+1}{n-1}$. The variation of u' with γ_1 for $n = 4$ and $n = 10$, is shown graphically and by tabulated values. The limiting values of u' (*i.e.*, for horizontal flight) in these two cases are : 1·66 for $n = 4$ (at $\gamma = 75° 30'$), and 1·22 for $n = 10$ (at $\gamma = 84° 50'$).

The section concerned with the combined effect of gravitation and an atmosphere is not restricted to the work of Tsiolkovskii but also mentions some of Hohmann's data on air resistance.

Hohmann is also among the five other workers whose work is next surveyed. First, it is noted that Esnault-Pelterie pointed out that ordinary fuels were inadequate for the lunar trip and suggested the use of radium. Then follows a brief account of Goddard's theories on "reaching extreme altitudes," and Oberth's deduction of expressions for the most advantageous velocity and motion of the rocket for minimum fuel consumption, obtained by partial differentiation of the equation of motion (including a term for the effect of air resistance) with respect to velocity. Rynin also gives the results of some of Oberth's flight calculations; these take into account the variation of gravitation with distance from the Earth. The section ends with the results of Hohmann's calculations, a brief note on Valier and a tabular comparison of the results of the

various investigators (exhaust velocity, acceleration, and the mass ratios required for journeys to the Moon and planets). Needless to say, there is disagreement between the figures advanced by any two persons, the difference being greatest in the case of the Earth-Mars trip.

This volume concludes with a list of measurements to be made for purposes of navigation, a brief note on Hohmann's proposals for the use of braking ellipses in landing, Rynin's conclusions, and a short bibliography.

VI. *Superaviation and Superartillery.*

Volume six is only of incidental interest from an astronautical point of view; it is essentially concerned with terrestrial happenings rather than interplanetary ones, and we meet with the aeroplane and cannon rather than the spaceship. And not even only the *rocket* airplane at that; an appreciable portion of the book refers to piston-engined aircraft. In a work devoted to interplanetary communications this may seem out of place, but what author has not been guilty of padding at some time or another?

To start with, there is a table giving details and performance data of 74 types of aircraft in existence or projected at the time of writing (1929), graphs giving the improvement in speed, altitude, endurance and distance records over the period 1908–1929, and illustrated descriptions of some of the aeroplanes and flying boats. A glance at the records is sufficient to show not only the progress made by the aircraft industry in those two decades, but also to indicate that the rate of progress has been more than maintained in the succeeding twenty odd years. A glance at the photographs of some of the more advanced of the projects (flying wings) may lead to reflection rather than pride. Apart from the propellers, they resemble the "aircraft of the future" which are still written about. My own reflection led me to the thought that some of the more grandiose spaceship or spacestation projects that one reads about in the glossy magazines of to-day will no doubt still be projects in twenty (or fifty, or . . . ?) years time.

Rynin next discusses means of improving the performance of the aeroplane, including engine development, turbo-compressors, propeller design, energy balances, etc. By superaviation is meant the flight of an aeroplane at great heights at great speed; the term was not invented by Rynin, but had been used previously by Crocco and others. The theory given here covers the effectiveness of rockets compared with other engines, the aerodynamics of high-altitude aeroplanes and the mathematical theory of the rocket aeroplane (particularly those due to Crocco and to Hans Lorenz). An interesting design for a rocket bomber is reproduced from a Czech journal; in addition to the rocket motors in the rear of the fuselage, it is powered by two conventional engines driving four propellers (two pushing, two pulling) which can be retracted into the wing.

The second chapter, "Superartillery" deals mainly with long-range guns and cannon, such as that used by the Germans to bombard Paris in World War I. Once again, data pertaining to the more advanced designs at the time of writing are tabulated, and their trajectories are compared. An account of the dynamics of projectiles follows, attention being paid to air resistance. In an attempt to improve the efficiency of the cannon, electric guns and turbine cannons have been proposed. In one of the two turbo-cannon designs shown,

the projectile fits *over* the barrel of the gun, there being a long tubular extension leading back from the warhead. The upper end of this bore resembles the cups of a Pelton wheel as seen in section (but is no doubt intended to represent a cup-shaped depression with a central "peak"—which would have the same section, but would have the advantage of a centre of symmetry instead of the planes of symmetry of the Pelton buckets). The gases rushing out of the barrel of the gun would thus be deflected back, leaving the missile through ports facing backwards. The principle of the other design is the same, but it employs a differently-shaped projectile, and the barrel has a convergent-divergent bore. While the idea behind these designs is sound enough, there are obvious practical difficulties to be overcome in perfecting a safe and reliable design, if that be possible. However, it appears that a muzzle velocity of 850 m./sec. was obtained in experiments at Paris in 1917–1922.

Many types of electric gun have been proposed, using direct current, single-phase A.C., polyphase D.C., etc.; this is, of course, a mechanism closely connected with our old friend, the electromagnetic launcher. Various projects put forward by Russian, French, Swiss, German and other inventors are mentioned; one of the earliest, by an Austrian named Hoefft, was in fact intended as a launcher for space vehicles. Experiments with models were made independently in Russia around 1913 by G. A. Polevoi and by Professor B. P. Veinberg.

As the range of a gun is increased, new factors responsible for deviations from the simple theory will be introduced; among these factors are the rotation of the Earth, changes in the gravitational force, and the motion of the atmosphere. After considering these, Rynin passes to the rocket projectile, but in the light of our knowledge of the German giant missiles and other military rockets, the information given is necessarily primitive and far out-of-date, mainly concerning rocket-propelled missiles shot out of guns, or winged rocket projectiles. Of rather more interest is the description of ballistic tests for rockets, devised by N. Zhirov at the artillery school in Kiev.

"The Shell of Atmosphere" is the title of Chapter 3; the Russian word *Pantsyr'* which I have translated as "shell" also, and perhaps more usually, means "armour." This serves to remind us that while our atmosphere might be termed a shell in the more figurative or mathematical sense of the word (an enclosing surface or thin layer), where meteorites are concerned, despite its gaseous nature, it behaves as a shell in the more precise meaning (a hard outer case) and protects us from their impact. To the returning spaceship, of course, the atmosphere might appear as rather a mixed blessing. In Chapter 3, Rynin is concerned with the properties of the atmosphere and with air resistance. The properties of interest include change in composition, density, pressure and temperature with height, and much information is given in tabular and graphical form, together with empirical formulae derived by various investigators to express the variations concisely. However, this information is mainly of historical interest; to-day, with the exploration of the upper atmosphere more reliable data are now available.

The final chapter returns to the subject of "superaviation," and in particular to those aspects of the subject dealing with the fliers, not the machines. First

and foremost there is the effect of acceleration, as revealed in the catapult launching of aircraft and in various experiments; this is followed by a discussion of the weightless state and of the reduced gravitational pull on such bodies as the Moon and meteorites. Next, it is pointed out that conditions of temperature and pressure at great heights are such that aeroplanes would need hermetically-sealed cabins, as already used for balloons, and the occupants would need to be supplied with oxygen. This leads naturally to an account of equipment for supplying oxygen, including valves, masks, etc., and hence to other equipment needed by the pilot (illustrated by a cut-away photograph of an open-cockpit R.A.F. plane, taken, I imagine, from the *Illustrated London News*). The second half of the chapter (some 37 pages) is a detailed account of various types of accelerometer: oscillating ("mass-and-spring") systems, linear (pendulum, spring, liquid/gas, and moving mass types), space (three-dimensional), angular, and optical.

VII. *Tsiolkovskii.*

As the sub-title indicates, this volume is concerned with the life and achievements of Tsiolkovskii, one of the early rocket pioneers. At the time the book was published (1931), Tsiolkovskii's life had some four years to run, but the major part of his work would have been covered, for as Rynin points out in the preface, the 75th anniversary of Tsiolkovskii's birth was to be celebrated in 1932. Following the preface, Rynin gives a few brief biographical notes, then reproduces the following letter:

11th June, 1926.

Dear Nikolai Aleksevich,

I am sending you my autobiographical data. Perhaps they will not appeal to you, but I cannot give you, and you did not ask for, anything more.

I see nothing against your kind intentions [to write this book] *and I thank you for it. I am sending my photograph. It was taken in the summer of* 1924. *This letter can serve you as an autograph* [foreword] *to your article about my works.*

In Moscow a brass model of the envelope of my dirigible was made according to my design. It occupies the large workshop in the communist university. It produces a deep impression and gives credit to the practicability of a metallic dirigible. The length of the model is 10 *metres, the height is two metres. Whether the work will be continued, I really don't know.*

With the highest esteem, I remain,

K. Tsiolkovskii.

As the Autobiography is of interest, it is reproduced below in full:—

Autobiography of K. E. Tsiolkovskii

"I was born on September 5, 1857 in the village of Izhevsk, Spasski district, Ryazanskii province. My parents were poor, my father a failure, inventor and philosopher [*a forrester—N. A. Rynin*]. Mother, according to

father, concealed a spark of talent. Among the relations, mother's were the more clever.

I was eight or nine when my mother showed us, as children, a collodion balloon. It was tiny, inflated with hydrogen, and interested me then as a boy.

In my tenth year I grew deaf from scarlet fever, and my hearing returned badly. With persons of the same age and in company I often got into difficulty, and naturally was comical with my deafness. This banished me from people and forced me from boredom to read, to be self-centred and to dream. Wounded self-esteem searched for satisfaction. The desire for exploits, for distinction, appeared and at the age of 11 I began to write the most absurd verses.

At 14 I obtained some theoretical notion about the balloon from the physicist Gano. I attempted to inflate a bag of tissue paper with hydrogen, but the experiment was not successful. It appears that I then was strongly fascinated by mechanical flight with the aid of wings. I also made a bad lathe, on which nevertheless it was possible to turn, constructed various machines, and among the rest a carriage which ought to have gone in different directions with the aid of the wind. The model succeeded beautifully and went against the wind on the roof on a board. Father was very pleased and the inventors stripped off the roof in order to show the machine to guests in the room. Here the experiment also succeeded brilliantly. I produced the wind with the help of bellows.

Next I began to build a carriage for my own travelling, giving up breakfast in order to spend money on nails and other stuff. But this exploit was not crowned with success: I became partly short of patience and materials, partly tired of hunger, and partly came to understand that this thing was impracticable and not worth a straw.

Simultaneously I had another model going on the ground; a carriage driven by a steam engine of the turbine type.

I was then a little interested in aeronautics, particularly gaseous [*ballooning*]; at 15–16 I became acquainted with elementary mathematics and could then study physics more seriously. Most of all I took a fancy to the balloon and already had sufficient data to decide the question: what must be the dimensions of a balloon for it to rise in the air with people, it being made from a metallic envelope of definite thickness. It was clear to me that the thickness of the envelope could increase infinitely with increasing dimensions of the balloon. From this time the thought of a metallic balloon was planted in my brain. Sometimes I tired of it, and then I was interested in other ideas, but in the long run I returned to it again. I learnt little systematically, particularly later on: I read only those things which could solve for me those questions which were interesting to me and which I considered important. Thus, the study of centrifugal force was interesting to me because I thought of applying it to the ascent into cosmic space. There was a moment when it seemed to me that I had decided this question (at 16 years old). I was so excited, even stunned, that I did not sleep the whole night—I strolled about Moscow and continually thought about the great consequences of my discovery. But by the morning I was convinced of the falsity of my invention. The disappointment was just as strong as the enchantment. This night left a trace in my whole life, after 30 years [*presumably* 60 *years*] I still sometimes dream that I am rising towards

the stars in my machine and feel the same rapture as on that unforgettable night.

I paid a little attention to "Perpetuum mobile" [*perpetual motion*], but, glory to God, the delusion lasted only for some hours, and the reason for it was incorrectly-understood magnetism.

The thought of space-travel never left me. It spurred me to study higher mathematics. Then in 1895 I carefully expressed my various deliberations on this topic in the paper "Dreams about Earth and Sky," and further (1898) in the work "Investigation of World Spaces by Reactive Devices," printed in *Nauchnyi Obozrenie* (No. 5, 1903).

Astronomy fascinated me because I considered, and still consider, not only the Earth but partly also the universe the property of the human race. My story "On the Moon," and articles "Gravitation as a Source of World Energy" and others show my unremitting interest in astronomy.

Books were then scarce, with me in particular. Therefore I had to think more independently, and even to go along an incorrect way. Often I invented and discovered what had long been known. I was studying, creating, although often unsuccessful and too late. Thus, even in 1881 I was working on the theory of gases, not knowing that I was too late by 24 years. On the other hand I became accustomed to think and to approach everything critically. However, I think originality was in my nature. Deafness and involuntary withdrawal from society only extended my self-help.

Lack of books and teachers did likewise; deafness deprived me of school, although I was obliged later on to pass the examination and to obtain a certificate. I was a teacher of mathematics and physics for nearly 40 years (since 1871). About 500 male and 2,000 female students passed through my hands, finishing middle school.* Apart from the limited number and dubious quality of the books I had no teachers at all, and can consider myself an absolutely self-taught man.

I so became accustomed to independent work that in reading textbooks I considered it easier to prove a theorem without the book than to read out the proof from it. Only I was not always successful.

At 23–24, being already a teacher, I submitted a series of my works—"Theory of Gases," "Mechanics of Living Organisms," "Duration of Radiation of a Star"—to the St. Petersburg Physico-Chemical Society. Their contents were somewhat belated, i.e., I had made independently discoveries already made earlier by others.

All the same the Society paid great attention to me, which kept up my spirit. Perhaps it has forgotten me, but I have not forgotten Borgman, Mendeleev. Fander Flit [*van der Fleet*], Bobylev, and in particular Sechenov.

At 25–28, I was very keen on the improvement of steam engines. I had steam engines made of metal and even of wood (the cylinder was actually wood), both worthless but nevertheless real.

In passing, I made a blowing engine that wasn't bad and various pumps,

* In 1882, a teacher in the chief school in the town of Borovsk, Kaluzhsgii province, from 1892, teacher of the diocesan school for girls in Kaluga.

which I never sold but made only out of curiosity and for an experiment in soldering and forging.

After some years I abandoned all this, because I saw clearly how I was impotent in technical respects in the realization of my ideas; therefore in 1885, being 28 years old, I firmly decided to return to aeronautics and to work out theoretically a metallic dirigible. I worked almost continuously for two years. I was always a passionate teacher and came weary from school, since the greater part of my spirit remained there. Only towards evening could I begin my calculations and experiments. What was to be done? My time was little, and also my strength, which I gave away to the students; and I began to get up at daybreak and having worked upon my thesis to set off for school.

After two years of this stress, I had a pain in the head for a whole year. Be that as it may, in Spring 1887, I made my first published contribution about the metallic dirigible in Moscow in the amateur society of natural science. I was treated rather kindly and sympathetically by them, particularly by Ya. I. Veinberg. They made insignificant objections, which it was easy to answer. More serious objections could have been made but were not, thanks to their small acquaintance with aeronautics and the defects of my manuscript. It contained about 120 written sheets (480 pp.) and 800 formulae (the aim also now). Professor Stoletov passed it on for examination by Professor Zhukovskii. I did not consider my work complete and even asked for no reference to be made to it except only for use in my matter of a transfer to Moscow.

This was promised to me, but for various reasons the transfer did not take place. I was completely ill, lost my voice, fire destroyed my library and my models, but the manuscript was then with Prof. Zhukovskii and I have kept it until now. It is entitled "Theory of the Balloon." After a year I had recovered a little and again set to work.

In the autumn of 1890, through the agency of D. I. Mendeleev, I sent to the Imperial Russian Technical Society my new work "On the Possibility of Constructing a Metallic Dirigible." Together with that I sent a model of the dirigible, folded up flat, 1 arshine [71·12 cm.] long. Presently from the journal I learnt that the Society found my calculations and ideas completely correct. Next they sent to me a copy with the opinion of Section VII of the Technical Society. Naturally, this opinion filled me with a certain amount of cheerfulness.

Work on flight by means of wings showed me that this method would demand much greater amounts of energy than there seemed from a superficial glance, which was afterwards confirmed in practice. Following this, I again inclined towards the balloon. I remember very intensive investigations were made by me for a new work entitled "Metallic Dirigible: Steering." One of my brothers and my acquaintances helped me to publish it in 1892. It seems that I never experienced such bliss as on obtaining (already in Kaluga) the proofs of this work.

In 1894, I returned to my former enthusiasm for aeroplanes, printing in the magazine "*Nauka i Zhizn'* " [*Science and Life*] the theoretical investigation "Aeroplane," but also in this work I indicated the advantage of gaseous, metallic flying vessels.

The works on the balloon and aeroplane suggested ideas to me for carrying

out experiments on air resistance. G. Pomortsev and other theoreticians found the resistance of balloons to be enormous. My experiments showed that it was far from being so appreciable and that the coefficient of resistance decreases with increasing speed of the balloon. The experiments were carried out partly in a room, partly on the roof in a strong wind. I remember how elated I was when the coefficient of resistance in a strong wind appeared small; I rolled almost head over heels off the roof and did not feel the ground under me.

The sympathetic press for my works was accompanied by gifts from various individuals in the aeronautical business. In all I received 55 rubles, which I used to carry out new experiments on air resistance. I took this money with gritted teeth and concealed mental pain, since some, not understanding the article of Golubitskii printed about my works in "*Kaluzhskii Vestnik*" (1897), directly gave to poverty. I even fell ill, but nevertheless endured, hoping for the possibility of further work. But, alas, in spite of the considerable noise of the newspaper, the sum seemed too insignificant. Thus, Piter sent 4 rubles but it cheered me up that his mite did not insult me, being given only to aeronautics. Be that as it may, thanks to the Society also for that, since I explained myself a good deal by the experiments which I made and which, together with the construction of my apparatus, were described in the *Vestnik Opytnoi Fiziki* in the article "Pressure of the Air on Surfaces Introduced into a Natural Air Stream" (1899). This work was submitted by me to the Imperial Academy of Sciences. Academician Rykachev made a favourable report on it to the Academy, which thanks to this gave me at my request 470 rubles for the continuation of the experiments.

After a year and a half I sent to the Academy a detailed report on my experiments, consisting of 80 written sheets of text and 58 tables and diagrams. A short summary of this report was later printed under the heading "Air Resistance and Aeronautics." After this work, for some time I continued my experiments, which, connected partly with various calculations, gradually made clear to me the true resistance of the air. Every laborious step brought me nearer to it and was more correct than its predecessor, but even the last of my steps did not bring me finally to the absolute truth.

I should have still wished to undertake this voyage by ways of truth but where was I to obtain the strength, where to obtain the means and support? In my experiments I drew many new conclusions, but new conclusions are met by the learned with distrust. These conclusions can be confirmed by repetition of my work by any investigators, but when will this be?

It is difficult to work in solitude for many years, under unfavourable conditions, and without seeing anywhere a ray of hope or support. It is true that occasionally I did meet with sympathy. For example, in Kaluga a whole group of practical technicians considered my project for a flying vessel to be feasible. Why after this not hope that it would be taken in the same way by all thinking and knowledgeable people. But then realization was not far off.

In the twenties, because of weak health, I left teaching. Although in lectures I spoke better than I heard, although I did not like the examination of pupils, this did not prevent me from liking my teaching work. Only it took away

from me all my strength and left very little for increasing my knowledge and for independent work. I wrote, calculated and worked with my hands most of all at festivals and vacations.

I worked on some aspects of the problem of ascending into space with the aid of reactive devices, especially the rocket. Mathematical conclusions, based on scientific data and verified many times, indicate the possibility of rising into celestial space with the aid of such devices, and perhaps setting up a colony at the limits of the terrestrial atmosphere. Probably a hundred years will pass before the opinions expressed by me find application, and people use them to disperse not only on the face of the Earth but over the face of the whole universe.

Almost the whole of the Sun's energy is lost without use to humanity at the present time (the Earth receives two thousand million times less than the Sun emits). What is strange in the idea of using this energy? What is peculiar in the thought of using also the unlimited space surrounding the terrestrial globe? In any case, is it necessarily wrong to express similar ideas once they appear as the fruit of serious work.

It seems that my hardness of hearing from childhood told in a complete ignorance of life and an absence of connections. Perhaps this served also as a reason why even after 68 years of my life I have not risen in the world and have not had real success.

All my life consisted in meditation, calculation, practical work (I suffered two hernias) and experiments. I always had a home-made workshop. If it was destroyed, for example, by fire or flood then I set it up or enlarged it again.

It is tedious to speak of myself and my trivial life, when there remain so many unsolved questions, unfinished or unpublished works. The most important are still ahead. Have I the strength, am I able to accomplish these proposed works?

Konstantin Tsiolkovskii.

This rather plaintive account of his early life gives one the impression that Tsiolkovskii was a rather embittered man who had been denied recognition, but that is no doubt partly due to the Russian temperament. At any rate, immediately after this item Rynin lists Tsiolkovskii's published articles, and there are over 90 of them; some 50 odd manuscripts were also listed. Evidently he did not lack opportunities to express his opinions, but only to put them into practice.

In these days of jet planes it may seem strange that one who was a pioneer of astronautics (as the second part of this book shows) should also be greatly interested in balloons and airships, but it must be remembered that at the time this book was issued the aeroplane had not reached its present ascendency over the lighter-than-air vessel. As described in Nevil Shute's recent biography, *Slide Rule*, it was even thought in the late twenties that the airship would be superior for transoceanic flights.

Before leaving Tsiolkovskii, the man, to discuss his work, it may be as well to add a note about the spelling of his name. Several variants have been used in non-Russian literature. This is because Russian is written not with the Latin alphabet used in most of the European countries, but with the Cyrillic

alphabet, which has thirty-six letters, each representing a single sound. In converting proper names from Russian into English, each Russian letter can be replaced by a single Latin letter or combination of letters (such as Ts or Shch) representing the corresponding sound—this is termed transliteration. When a name has been transliterated according to the scheme which is in almost universal use in English-speaking countries, it is easy to know how to pronounce it fairly correctly, to convert it back to the correct Russian form, or to locate the person concerned in indexes, etc. However, this scheme only holds for English-speaking countries; elsewhere the Latin letters may or may not be pronounced differently. Hence, in German-speaking countries the name would be written *Ziolkovsky*, the German "z" being similar to our "ts" (as in "bits"). There is no point in translating Russian names into German for English readers, however.

Mr. E. Bialoborski has already pointed out that the name itself is of Polish origin (*J.B.I.S.*, 1950, **9**, 257), then being written *Ciolkowski*, and that Tsiokkovskii's father was born a Pole. Evidently he decided to settle permanently in Russia, however, and his son was born there, so that our man can only be described as a Russian of Polish descent. He would naturally use the Russianized form of the name, and that was of course used in printing his books and articles and would therefore be used here for bibliographical purposes.

(To be concluded)

RECENT RESEARCH ON THE MOON—1. OUR CRACKING SATELLITE

By H. Percy Wilkins, F.R.A.S.

SUMMARY

This is the first of a series of articles on the Moon in which will be described the writer's most recent researches conducted with some of the largest telescopes. The present article deals with the mysterious clefts, or cracks, and presents evidence that these strange features may be on the increase.

Introduction

After reading certain statements in recent books and articles, some people have assumed that evidence has been obtained of industrial activities taking place on the Moon, such as the landing or taking-off of "flying saucers," the construction of embankments and the excavation of tunnels—so it is important to place on record the results of the most recent researches. This has become a matter of urgency because the uninitiated do not appreciate that only too often sensational statements emanate from those who are in no sense authorities on the subject and, indeed, have never studied the Moon. The more sober results of research workers attract little attention but it must be realized that these results form the sole basis upon which all theorizing respecting the Moon's past, present and future must be built. The purpose of these articles is to inform readers as to the precise extent of our knowledge of certain selected lunar regions so as to provide a basis of fact upon which subsequent theorizing can be undertaken by readers themselves.

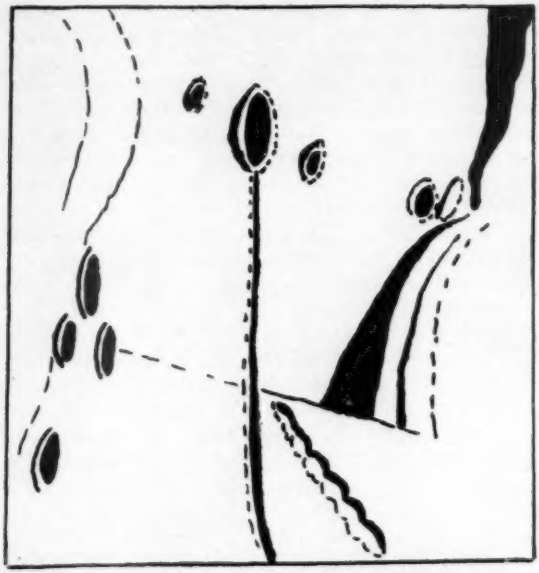

Fig. 1. Vendelinus. (Elger, 1891.)

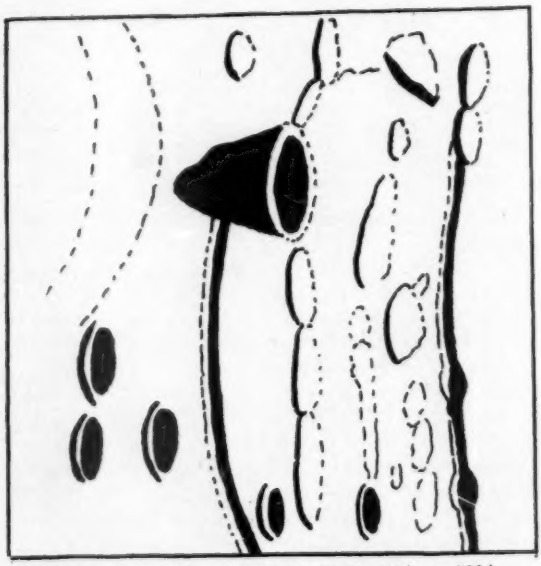

Fig. 2. Vendelinus. (Wilkins, 1954. 60 in. × 500.)

Telescopes Used

The particular researches referred to concern telescopic observation of the lunar surface features undertaken by the writer while in the United States. With traditional courtesy and hospitality the giant American telescopes were freely placed at his disposal while the favourable weather and excellent seeing conditions enabled some very interesting and highly significant results to be obtained. The instruments used were the 60-in. reflector at the famous Mt. Wilson Observatory in California, and the 26-in. refractor at the Naval Observatory, Washington, D.C.

The Mt. Wilson Observatory is situated about 25 miles from the city of Los Angeles and the mountain rises 5,710 ft. above the level of the Pacific Ocean. Although this part of the coast is subject to considerable fog spreading in from the ocean, this generally only covers the low-lying district, leaving the mountain top in a serene and very transparent atmosphere, free from interference by the city lights. The Observatory was founded for solar research (which has been undertaken with the 100 ft. and 60 ft. tower telescopes and with the "Snow" instrument) but stellar, and to some extent, lunar and planetary work is accomplished with the 100-in. and 60-in. reflectors. The latter is a massive and very rigid instrument of high optical quality and is driven by mechanism of the highest perfection contained in the base below the observing floor. So excellent is the mirror and so rigid and perfect the drive that it is possible to STAND on the massive cell without introducing vibration! The writer conducted his observations with one foot on the tall observing ladder and the other on the tube itself as the image was formed at the Cassegrain focus which, in this arrangement, is at the upper part of the tube and near the surface of the great 5 ft. diameter mirror.

The 26-in. refractor at the Naval Observatory, Washington, D.C. is housed in a conventional dome with a rising floor, and is equipped with a superb objective by the celebrated maker, Alvan Clarke. With this instrument Prof. Asaph Hall discovered the two satellites of Mars in 1877 but since that time the telescope has had a new tube and mounting and is maintained in first-class condition. The driving clock functions admirably, rendering observation both easy and a pleasure, while all the controls are brought conveniently to the eye-end. The only disadvantage is that the instrument is not situated on a mountain top but in the extensive grounds of the Observatory within the city limits and conditions are, therefore, seldom as favourable as at Mt. Wilson.

On the way to Mt. Wilson the road from Los Angeles passes through the suburb of Pasadena and then along the plains to the foothills where it begins to ascend as a winding mountain road. In places the narrow road winds amid magnificient mountain scenery, thickly wooded hills rise on all sides separated by deep canyons, the road here dipping down and then swooping in hair-raising bends upwards to the Observatory gates, beyond which the public are not admitted. But the writer was in a privileged party and soon alighted near the 100-in. dome, but not in its shadow as the Sun had already set over the Pacific Ocean, the water of which shone like burnished silver in the far distance beyond the mountain ranges. By the end of twilight—the Moon, two days after full,

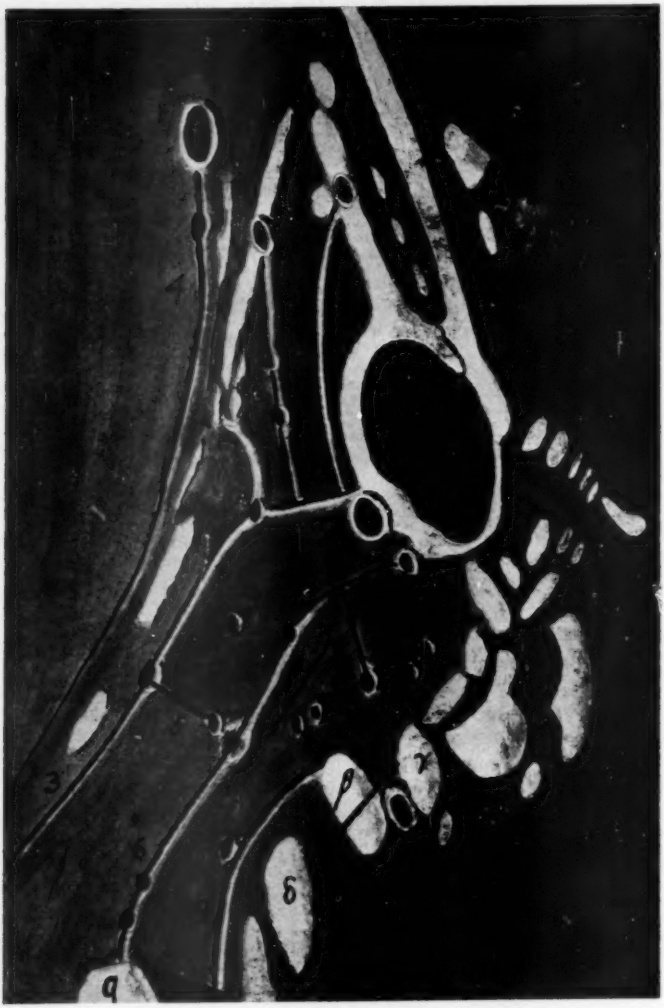

Fig. 3. Cracks in the E. border of Mare Humorum.

and Mars to its west, shone with a brilliancy almost unknown in England while, despite the moonlight, fourth magnitude stars could be seen with the naked eye right down to the horizon. Inside the 60-inch dome, after observing Mars, the telescope was directed to the waning Moon and, using a magnifying power of 500, attention was directed to the formations along the terminator, the dividing line between the light and the dark portions. After the great dark plains, misnamed Seas, the characteristic features of the Moon are the strange ring-like objects, the crater mountains. Among the less obvious but even more interesting objects are the mysterious white rays and the numerous cracks or clefts, some of which are clearly shown on the fine lunar photographs of to-day.

Cracks and Clefts

The first glance through the great telescope showed everything very brilliant, as might have been expected from the great aperture used. Advancing night had concealed the greater portion of the little plain known as the *Mare Crisium*; south of this the great craters of Langrenus, Vendelinus and Petavius stood out in giant relief.

On December 17, 1891, T. Gwyn Elger, first director of the British Astronomical Association Lunar Section, observed the crater of Vendelinus with his 8½-in. Calver reflector and saw a cleft or crack running north from a small crater on the nothern part of the interior.[1] Subsequently this cleft was again recorded by Elger himself and also by Maw, a well-known observer who possessed a 6-in. refractor. A certain amount of controversy followed as to whether this crack is continuous or, as some observers asserted, only a part can be seen. The writer and some other observers, including Mr. Robert Barker, have failed to find a trace of it. When the Moon was observed with the 60-in. telescope under an almost identical angle of illumination to what it was in 1891 when Elger saw the cleft it seemed the time to settle the matter for if the cleft was seen in a 8½-in. telescope it should certainly be a glaring object in a 5-ft. instrument.

Not a trace of the alleged cleft was seen—in fact, where Elger drew the cleft a series of low and long mountains or mounds were detected. But the high-powered telescope revealed two new clefts not seen by Elger or for that matter by any other observer. (Figs. 1 and 2.) The cleft to the right or the east passes through two craterlets and both clefts are wide and deep.

Here then we have a feature seen by independent and capable observers which now does not exist. Even more strange is the fact that where sixty years ago a cleft or crack (that is, a depression) was seen, there is to-day a series of hills, i.e. elevations! Equally strange is the fact that although a cleft has vanished and to all appearances filled up, two new ones have opened up, one on either side. Possibly here we have evidence of recent cracking of the surface of the Moon.

The 26-in. refractor at Washington is much smaller than the instrument at Mt. Wilson but is nevertheless a fine example of optical skill. Again it was a fine night with a brilliant Moon, this time less than four days before full, with the eastern part of the little plain known as the *Mare Humorum* just coming into the sunlight. (Fig. 3.) It has long been known that the border of this plain is extensively cracked but once again the very first glance through the

telescope revealed that it was much more cracked than anyone had hitherto suspected.[2] Goodacre in his map of the Moon (1910),[3] only shows cracks 4 and 6 and part of 5 which he depicts as running into 6. The classical map of Schmidt,[4] 1876, shows 2 and 4 as ridges, 6 as a crater-chain and 9 as a cleft, while Neison in his book *The Moon*, 1876, shows what may be either clefts or ridges but seems to show 6, marked Epsilon, 9 marked Beta and 3 marked Eta. No. 4 was shown as a ridge.[5]

Thus the clefts 1, 7, 8, 10 and 11 seem to be new and 4 shown by the older observers as a ridge is now definitely a cleft. Has what was a ridge sunk down and become a cleft and how can we explain the undoubted existence of new cracks in this often observed region? Is it possible that here also we have evidence of recent cracking of the surface of the Moon.

The above are only two examples taken from a considerable body of evidence which suggests that cracks are still being formed on the Moon. In the next article we will show that other features such as the dusky streaks and domes seem also to be changing.

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CONDITIONS ON THE SURFACE OF MERCURY

By Patrick Moore, F.R.A.S.

When the subject of space-flight is mentioned, the average person thinks immediately of the Moon, Mars or Venus. There is a great deal of sense in this. The Moon, although a decidedly inhospitable world, is by far our nearest neighbour in space, and, as far as we are concerned, has a status that is unique; Venus has an atmosphere of a kind, and although the modern fashion is to dismiss it as an arid dust-bowl, we cannot as yet be certain that the alternative picture of the surface as being humid and covered with vegetation is totally wrong. Mars is, without doubt, the most inviting of our planetary neighbours —there is atmosphere, there is a little water, and there is almost certainly vegetation.

However, it must never be forgotten that there are eight planets and thirty satellites in the Solar System (excluding the Earth and Moon). Some of these, such as the icy giants, are totally unfitted for any landings; others, such as the dwarf moonlets of Mars, hardly merit the title of "satellite" at all. Yet it would be a grave mistake to reject all the others, such as the methane-mantled Titan, sixth satellite of Saturn; and in particular we must pay some attention to Mercury, closest to the Sun of all the planets.

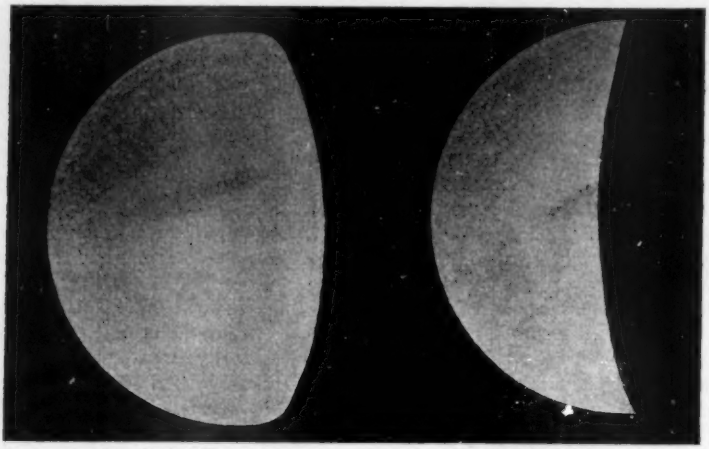
There are a great many people—including amateur astronomers—who have never seen Mercury. It is never very conspicuous to the unaided eye, though bright enough at times, and only occasionally can it be seen glittering low down

in the west after sunset, or in the east before sunrise. There is a well-known story that Copernicus, the great astronomer who revived the ancient theory of a Sun-centred Solar System, never saw Mercury at all—owing to the mists rising from the river Vistula, near which he lived—and lamented the fact on his death-bed; and although this story, like those of Newton and the apple and Galileo dropping stones off the Leaning Tower of Pisa, is probably nothing more than legend, it does stress the fact that Mercury is not easy to glimpse. In some ways, it is rather surprising that it was known in ancient times, but the old Greeks and their predecessors were thoroughly familiar with it. Fittingly enough, it was named after the messenger of the gods—elusive Mercury, whom Nathaniel Hawthorne called "Quicksilver," of the winged sandals and the snaky staff.

Mercury revolves round the Sun at an average distance of 36,000,000 miles. though this varies considerably owing to the fact that the orbital eccentricity (0·206) is greater than that of any other major planet apart from Pluto. The minimum distance from the Earth is thus a little less than 50,000,000 miles; and as the diameter of Mercury is only 3,100 miles—not much greater than that of the Moon—it is not surprising that our knowledge of the surface conditions there remains rather meagre. Small telescopes will show almost nothing. I have often seen faint markings with my own 12½ in. reflector, but so vaguely that they are difficult to draw and impossible to map accurately; and the complicated charts that are sometimes produced by workers using very small instruments cannot, unfortunately, be relied on. As a matter of fact, our information about the Mercurian surface comes from only three sources: the observations made during the latter part of the last century by Schiaparelli, the detailed work of E. M. Antoniadi at the Observatory of Meudon some 25 years ago, and the more recent investigations by Dr. Audouin Dollfus and his colleagues at the Pic du Midi. Many other drawings have been made, and no account of Mercury would be complete without a tribute to the splendid labours of Henry McEwen, of Glasgow, who has directed the Mercury and Venus Section of the B.A.A. most efficiently ever since 1895, and is still a most active observer. But when discussing the Mercurian markings, we come back every time to the work done at Meudon and the Pic.

Sir William Herschel, the great astronomer who discovered Uranus and is rightly regarded as the true founder of stellar science, was able to detect almost no markings on Mercury even with his great 40-ft. reflector. His contemporary Johann Schröter, who also has his place in history as being the first of the great observers of the Moon, did detect markings, but unfortunately he was no draughtsman, and some of his conclusions were patently wrong—for instance, he believed that he had found a mountain eleven miles high! It was not until 1881 that Giovanni Schiaparelli, at Milan, turned to the problem, and produced the first proper chart of the surface features.

Schiaparelli will always be remembered for his connection with the canals of Mars, but his work on Mercury was just as valuable. He recognized the fact that when the planet can be seen with the unaided eye, just before sunrise or just after sunset, it is so low down that its disk is bound to be blurred by the tremors in the Earth's atmosphere; and so he preferred to make his observations



1951 March 30, 19h. 8½ in. Refl. × 250.

1951 April 5, 19h. 8½ in. Refl. × 250.

MERCURY.

in broad daylight, with the Sun well above the horizon. Between 1881 and 1889 he made a large number of drawings, and his chart compares well with those made in later years at Meudon and the Pic. His first conclusion was indeed remarkable. He announced that Mercury's "day" is the same length as its "year"—88 terrestrial days—and that consequently Mercury always keeps the same hemisphere turned towards the Sun.

We have a much more familiar analogy of this sort of behaviour in the rotation of the Moon, which keeps the same side turned towards the Earth; and although some people have difficulty in understanding it, it is in reality quite easy to appreciate. The best practical illustration is to take a chair and walk once right round it, keeping your face turned towards it all the time. When you have completed one circuit, you will have turned once upon your axis; and this is how Mercury spins—if you take the chair as representing the Sun and your head as representing Mercury. There is no mystery about it. Tidal friction is responsible. In its early days of separate existence, Mercury no doubt revolved rapidly; but the Sun raised huge tides in its viscous body, and did its best to keep the heaped-up tidal bulge turned sunwards, so that gradually Mercury's rotation was braked until it could manage no more than one turn every Mercurian "year." Antoniadi's researches have shown that most of the satellites of the larger planets keep one face turned permanently towards their primaries, so that Mercury's peculiarity is not fundamentally unique, though it does seem to be the only major planet that keeps the same hemisphere turned permanently sunwards.

If the orbit were perfectly circular, Mercury would thus have one hemisphere of perpetual day and one of perpetual night. However, the orbit is decidedly elliptical; and the planet's speed varies from about 36 miles per second at perihelion (nearest point to the Sun) to only 24 miles per second at its farthest

point from the Sun. This means that the axial rotation and orbital position are often "out of step." The Sun therefore seems to sway to and fro in the Mercurian sky, and there is a wide belt where it moves alternately above and below the horizon; astronomers call this the "twilight zone," and here, if at all, the explorers of the future will land. There is, of course, an area of everlasting sunlight, and also an area where the Sun will never rise at all.

For many years, Schiaparelli's map[1] remained the best. He made almost no observations after 1890, owing to failing eyesight—it is tragic to record that eventually he became totally blind—and we can at once dismiss the curious chart of Professor Percival Lowell,[2] who covered Mercury with a network of canal-like markings not unlike those which he recorded on Venus, on Mars, and on almost every other planetary body that he observed! Many drawings were made by McEwen, Denning, and others; but the next step was taken by E. M. Antoniadi, a Greek astronomer resident in France, who started work with the great 33-in. refractor of the Observatory of Meudon, and summarized his results in a small book.[3]

As I have made extensive observations with this instrument, I can state from personal experience, as well as from hearsay, that it is one of the finest refractors in the world; it is also the largest in Europe, and Antoniadi himself was a magnificent observer, so that it is hardly surprising that he saw more than Schiaparelli had done. His chart, published in his book and recently reproduced in a work of my own,[4] shows a number of well-defined dusky markings against the generally pinkish background, and is in good general agreement with Schiaparelli's. Antoniadi also named the principal features, and his nomenclature has been generally accepted; though some of the names are cumbersome—the main dark marking is called the Solitudo Hermae Trismegisti, or "Wilderness of Mercury the Thrice Greatest"; others are Phaethontias, Solitudo Criophori and Solitudo Persephones—they are a distinct improvement upon those given to the dark lava-plains of the waterless Moon! Like Schiaparelli, Antoniadi made most of his observations in broad daylight; and he agreed with Schiaparelli that the revolution period was equal to the orbital period of 88 days. This fact can, indeed, be regarded as completely established.

Needless to say, it took Antoniadi some years to draw up his chart. Mapping the planet is complicated by the fact that Mercury, being nearer to the Sun than we are, shows phases; we see it as a crescent, as a half, or as gibbous (between half and full)—when it is actually full it is so close to the Sun in the sky that it is almost impossible to observe at all. A good chart could not have been made without the aid of a giant telescope with tremendous light-gathering power. Yet both Schiaparelli and Antoniadi were convinced that the various markings showed alterations in appearance; small dark patches, such as the Solitudo Maiae and the Solitudo Phoenicis, were sometimes relatively prominent, sometimes obscure. The only reasonable explanation seemed to be the existence of clouds. Antoniadi wrote that in his opinion, the clouds of Mercury were "more frequent and obliterating than those of Mars." It was never suggested that these clouds were at all like ours; we cannot picture any form of aqueous vapour upon a world like Mercury—yet even if they were made up of dust, their very existence involved the presence of a tenuous atmosphere.

As a matter of fact there was no theoretical bar to the existence of such an atmosphere. Mercury's escape velocity is 2·6 miles a second, so that it should be capable of retaining a very tenuous atmospheric mantle. On the other hand, it was clear that such a mantle would be extremely difficult to detect at a distance of over 50 million miles; remember that it is still uncertain whether the nearby Moon has an atmosphere, or whether it is totally airless. (Recent observational work seems to indicate a lunar atmosphere with a density of perhaps 1/10,000 of that of our own, but definite proof is still lacking.) When Venus passes in transit across the face of the Sun, the outline of the disk is blurred and hazy, owing to the dense Cytherean mantle; but when Mercury transits, as it did in November 1953 and will do again in November 1960, its outline is perfectly sharp and clear-cut. Strange appearances have been recorded from time to time, but seem to be due to nothing more than observational errors or instrumental imperfections.

The question was not finally decided until 1950, when a tenuous atmosphere was discovered by Dr. Audouin Dollfus, at the Pic du Midi Observatory. The instrument used was the 24-in. refractor, and the method an indirect one based on polarimetric observations. In his paper,[5] Dollfus wrote that "we must attribute these differences in polarization to a feeble atmosphere whose pressure will be about 3/1000 of our own (assuming similar composition). The ground pressure will be in the region of 1 mm. of mercury. This atmosphere, however, is very hard to detect, and I propose to confirm it by more refined methods as soon as a suitable instrument becomes available for the purpose."

Needless to say, the composition is not likely to be at all similar to our own—it is much more likely to be carbon dioxide, or something of the kind—and the estimated pressure is bound to be arbitrary; but Dollfus' investigations do at least show that Mercury is not the utterly airless world so often described in text-books. How useful the air-mantle is likely to be to interplanetary voyagers is, of course, problematical. It will probably suffice to protect the surface from meteoric bombardment, but we cannot be certain, and it will be totally useless for respiration. Nor will the pressure be nearly enough to prevent the danger of blood-boiling, and the Mercurian space-suit will have to be of the same type as those employed on the Moon or in outer space.

Yet strangely enough, Dollfus and his collaborators do not support Antoniadi and Schiaparelli with regard to the question of clouds. Although the Pic refractor is appreciably smaller than the 33-in. used by Antoniadi, the seeing conditions at the Observatory are unsurpassed anywhere in the world—the altitude is something like 10,000 ft., above the worst layers of the terrestrial atmosphere—and in Dollfus' opinion the evidence in favour of atmospheric veils is totally inadequate,[6] so that the question has been thrown completely open again. This is one case where the amateur observer can do little or nothing to help; all that can be done is to await further information from observers working with great telescopes.

In the main, the Pic du Midi charts corroborate Antoniadi's so far as can be expected with so difficult an object as Mercury. Let us now turn to the probable nature and relief of the planet's surface.

It is hardly necessary to say that Schröter's eleven-mile high mountain

remains unconfirmed. The only hope of detecting a peak would, in fact, to observe it when near the "terminator," or boundary between the day and night hemispheres of the planet. We can see effects of this sort very well with the Moon; naturally, a peak will catch the rays of the Sun before and after an adjacent valley, and the lunar terminator is rough and uneven, as even binoculars will show. However, the Moon is 200 times as close as Mercury at its nearest, and if the Mercurian mountains were no higher than the lunar ones we could have no hope of detecting them in such a way. Dollfus has paid particular attention to the problem, and has stated[6] that "if the Mercurian relief were twice as great as that of the Moon, it should be detectable"; yet he has so far failed to do so. All we can say at the moment, therefore, is that although Mercury may be (and probably is) very mountainous, we have no definite proof either way.

Nor do we know whether there is much similarity between Mercury and the Moon. Our sateilite is a wild volcanic waste, pitted with huge craters that seem certainly to be igneous in origin; but if Bailly, the largest lunar walled plain (180 miles or so in diameter) were transferred to Mercury, it would be totally undetectable. It is, however, perfectly probable that craters exist. Mercury and the Moon are not dissimilar in size; they are alike, too, inasmuch as both are very poor reflectors of sunlight.

When we come to consider the surface temperatures, we are on rather more certain ground. Pettit and Nicholson, at the Mount Wilson Observatory, have made direct measurements, and have found that at the centre of the area of perpetual day the temperature rises at perihelion to 700° F.—enough to melt lead or tin. On the other hand, the tenuous atmosphere must be quite unable to convey any appreciable heat round to the area of everlasting night; and here, the temperature must be lower than anywhere else in the Solar System. Remote Pluto, at its distance of over three thousand million miles from the Sun, certainly spins on its axis more than once during its "year" of 248 terrestrial years, and this alone must raise the temperature above that of the night side of Mercury. It is not entirely correct, therefore, to say that Mercury is the hottest planet in the Solar System. More accurately, it is both the hottest and the coldest!

Only in one area will the temperature be bearable; and this area is, of course, the "twilight zone" between the areas of perpetual day and perpetual night. If we are ever to visit the planet, we must land in this region. But what are we likely to discover?

One thing is certain: on Mercury, where there is little atmosphere, no free oxygen and not a scrap of water, we are unlikely to find any living thing. It is within the bounds of possibility that very low-type vegetation may linger on inside some of the craters of the Moon, but even this is undoubtedly absent from Mercury. Intelligent life is so utterly out of the question that we need waste no no time in discussing it further. Nor will the planet welcome us; the journey there will be a difficult one, and it seems improbable that even in the centuries to come, when space-travel is an accomplished fact, there will ever be a permanent base on Mercury.

No; the "hottest and coldest planet" is an inhospitable world. Perhaps some explorers of the future will land in the twilight zone, to see a

grotesquely swollen Sun blazing down upon the cracked, barren surface; but they will not linger for long. A brief visit will be enough before they race away into the black Mercurian sky, leaving the strange little world to circle the Sun in everlasting loneliness and desolation.

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ASTRONAUTICAL FALLACIES

By Arthur C. Clarke, B.Sc., F.R.A.S.

During its brief history as a science, astronautics has managed to accumulate a remarkable collection of fallacies and delusions. Some of these have been trivial and would never have deceived anyone who had studied the subject seriously; others have been a little more subtle and have crept into the literature; and some, we cannot help fearing, may not be revealed until we get into space.

Fallacies are always amusing and are often extremely instructive, for it is by exposing them that one can obtain a better understanding of the facts that they conceal. So let us look at some of the prize specimens that have crept into the domain of astronautics.

The classic example, of course, is the "rocket won't work in a vacuum where there's nothing for it to push against" argument. This is still heard sometimes and occasionally crops up in the correspondence columns of the *Poona Evening News* or the *West Durban Gazette*. There was a time, however, when lecturers on space-flight could count on it appearing with monotonous regularity, even when they believed that they had given a lucid explanation of the rocket's functioning.

Incidentally, one can only regard with awe the olympian conceit of some of the critics who brought this argument forward. Apparently they were under the impression that, despite all the thought that a generation of scientists had given to the subject of space-flight, *they* were the first to wonder how a rocket really worked when it left the atmosphere.

There were two variations on this theme by people who had avoided the main fallacy. Some could understand (or thought they understood) how the rocket was propelled, but were unable to see how it could be steered—still less how it could get home again. It seems amazingly hard to get across the idea that a rocket can go back the way it came.

The second fallacy was rather more interesting. Those who quite agreed that a rocket would work in a vacuum sometimes wondered if an additional

push could be obtained at take-off by letting the blast impinge on a wall. In practice, the change in thrust would be negligible—but the damage produced by the reflected blast would be nothing of the sort.

An argument that used to be employed against space-flight by professional pessimists about twenty years ago ran something like this: "It takes 20,000,000 foot-pounds of energy to lift one pound out of the Earth's gravitational field. The most powerful propellant combination contains 5,000,000 foot-pounds of energy per pound. Therefore no propellant can even lift *itself* out of the Earth's gravitational field. Therefore space-flight is impossible. Q.E.D."

It is surprising how a few figures, quoted with a show of authority, can "prove" a case. (There is no need for the figures to be right as long as there is no one around who can contradict them.) In the example above, the figures were correct—at least approximately—but the interpretation was hopelessly wrong.

The propellants a rocket carries obviously do *not* have to "lift themselves out of the Earth's gravitational field." If they can be burnt and induced to give their energy to the rocket while it is still close to the Earth's surface, they are scarcely lifted at all. In the extreme case of a projectile fired from a perfectly efficient gun, just four pounds of the propellant quoted would send a one pound missile clear away from the Earth.

The most extraordinary suggestion we have ever seen concerning rockets, however, was made in perfect seriousness in an old astronautical journal by a gentleman for whom Sir Isaac Newton had obviously lived in vain. He proposed *catching* the exhaust gases, by means of a funnel behind the rocket motor, and using them over again. This scheme reminds one irresistibly of those cartoons of becalmed yachtsmen blowing furiously at their limp sails with a pair of bellows, and forgetting the incurable equality of action and reaction.

It is not surprising that some of the most interesting space-fallacies have involved gravity. We will not discuss here the whole range of fictional "anti-gravity" devices, many of which have their own built-in contradictions, but will concern ourselves with some proposals which at first sight seem quite sound and reasonable.

One of the first involves the question of jumping on a planet of low gravity, such as the Moon. On Earth, it is sometimes stated, a skilled jumper can clear six feet. On the Moon, where gravity is a sixth of Earth's, he could therefore jump thirty-six feet.

This is an error, owing to the fact that the greatest height a man can *really* jump on Earth is a mere two feet! For a jumper, at the moment of take-off, starts with his centre of gravity almost four feet from the ground, and his muscular effort merely lifts it another two. Assuming that he could put forth the same effort on the Moon, therefore, he could lift his C. G. twelve feet—and could hence clear a bar about sixteen feet from the ground.

Many years ago we read a science-fiction serial in which one of the characters jumped off Phobos, the inner moon of Mars, and was in danger of falling on to the planet below. This involves a fallacy to which we will return later, and it can be said at once that Phobos (diameter about ten miles) is too large a body to permit human beings to escape by muscle-power alone. However, there is no doubt that a man could jump off some of the smaller asteroids. The limiting

diameter, for an asteroid made of ordinary rock, is about four miles. Deimos may be near this limit, and the thought raises interesting possibilities for future athletic contests. Interplanetary high-jumping, however, would be almost as tedious to watch as cricket,* since it would be many hours before the slowly rising contestants had sorted themselves out into those who had achieved escape velocity and those who were falling back again. . . .

If anyone did succeed in jumping off Phobos or Deimos—even if he jumped directly towards Mars—there would be no possibility whatsoever of his falling on to the planet. In the case of Phobos, for instance, he would still possess the satellite's orbital velocity, which is almost 5,000 miles an hour. All that his jump would have done would be to compound this speed with the few miles an hour which his own muscles could provide. His velocity vector would therefore be virtually unchanged, and he would still be a satellite of Mars, moving in an orbit very slightly different from that of Phobos. At the most, he would recede a few miles from Phobos—and if he waited three hours and fifty minutes (half a revolution) the two orbits would intersect again and he would return to the surface of the little moon!

A number of writers have fallen into another gravitational trap by proposing that space-travellers should use asteroids or comets to give them free rides. Some asteroids, they point out, have passed within a few hundred thousand miles of the Earth and then gone on to cut across the orbits of the other planets. Why not hop aboard such a body as it makes its closest approach to Earth, and then jump off at a convenient moment when passing Mars? In this way your spaceship would only have to cover a fraction of the total distance: the asteroid would do all the real work.

The fallacy arises, of course, from thinking of an asteroid in terms of a bus or escalator. Any asteroid whose path took it close to Earth would be moving at a very high speed relative to us, so that a spaceship which tried to reach and actually land on it would need to use a great deal of fuel. And once it had matched speed with the asteroid it would follow the asteroid's orbit *whether the asteroid was there or not.* There are no circumstances, in fact, where making such a rendezvous would have any effect except that of increasing fuel consumption and adding to the hazards of the voyage. Even if there was any advantage in such a scheme, one might have to wait several hundred years before there was a chance for a return trip. No, interplanetary hitch-hiking will not work. . . .

The commonest of all gravitational fallacies is that enshrined in the words "How high must you go before you get beyond the pull of gravity?" In the public mind, the idea of weightlessness is inseparably tied up with escaping from the gravitational field of the Earth. It is extremely hard to explain in understandable language (*a*) that one can never "get beyond the pull of gravity" and (*b*) that one can be completely weightless while still in a gravitational field.

Perhaps the most complete misunderstanding of conditions in space that we have ever encountered was shown by a cartoon strip artist who depicted two

* I shall be safely out of England by the time these words appear in print.

spaceships being coupled together by *suction pads*. Presumably he had grown a little tired of seeing magnets, and had tried to do something original.

Though this is not a fallacy in the sense that it can be easily disproved by logic, it seems fairly certain that the fate which would befall the human body when exposed to the vacuum of space has been greatly exaggerated. Certainly there is no question of the body being severely damaged—or even exploding, as some writers have imagined. Men have been subjected, in explosive decompression tests, to greater pressure changes than would be experienced in a spaceship whose cabin walls were ruptured. It seems likely that the pressure in a spaceship cabin would be about a third of an atmosphere, perhaps less. Normal air contains only a fifth part of oxygen: the remaining nitrogen is so much ballast. By breathing *pure* oxygen at 150 mm. pressure instead of air at the normal 760 mm., the crew would still be getting just as much oxygen into their lungs as they would on Earth—and the structure of the pressure cabin could be made very much lighter because of the reduced stresses.

Actually it is not quite as simple as that, and some helium or other inert gas might be included in the artificial atmosphere of a spaceship. But in any case, the total pressure would not be much more than 200 mm.—say one-third of an atmosphere.

Men have stood almost instantaneous pressure drops of this magnitude: if you want to know what it feels like, go down ten feet in a swimming pool and come up as quickly as you can. It won't do you the slightest harm.

If a man is suddenly plunged into a vacuum, he will of course quickly lose consciousness owing to lack of oxygen. The time quoted for this to happen is about fifteen seconds, but there is little doubt that this could be greatly extended if there was time to make suitable preparations. Divers, by breathing deeply and so flushing out their lungs with air, can hold their breath for three or four minutes. As far as lack of oxygen is concerned, therefore, a man could certainly survive in space for at least a minute.

After a certain length of time, the absence of pressure would cause his blood to boil—but this would be quite a slow process since the veins and arteries are tough enough to provide considerable internal pressure, and the latent heat needed for the boiling process would have to come from somewhere. It seems plausible to assume, therefore, that short excursions into space could be tolerated, though we have never been able to get a clear "yes" or "no" answer from the medical experts on this point.

If this is the case, we can imagine the time when some of the tougher old hands on the space station or the lunar base won't bother to put on suits if a job can be completed in under a couple of minutes. And, of course, they will sometimes regret it. . . .

The suggestion was once made to us that when a spaceship was under power, the resultant acceleration would cause the air inside the ship to be compressed at one end so that the people "at the top" might suffocate. Fortunately, this novel danger doesn't bear serious analysis. The atmosphere inside a spaceship under one gravity acceleration would have exactly the same pressure gradient as it would on Earth. We have never heard of anyone suffocating because

they walked upstairs, though a sufficiently sensitive barometer would show that the pressure in the bedroom is slightly lower than in the kitchen. . . .

Designers of the five-mile-long interstellar spaceships launched by the more ambitious science-fiction writers would certainly have to allow for this effect, since the atmospheric pressure difference between the prow and stern of such a vessel would be as great as that between base and summit of Everest. However, one fancies that this would be among the very least of their worries. . . .

We will end by reluctantly demolishing an illusion which everyone must be very sorry to lose—and that is the popular belief that on the Moon, even in daytime, the sky would be blazing with stars and that the Sun's corona would be seen stretching out from it like a glorious mantle of milky radiance. The lunar landscape by daylight will be spectacular enough—but it will be as starless as the day sky of Earth.

When a large amount of light enters it, as is normally the case during the daytime, the human eye automatically cuts down its sensitivity. At night, after a period of some minutes, it becomes about a thousand times as sensitive as during the day. It loses that sensitivity at once when it is flooded with light again—as any motorist who has been blinded by an approaching car will testify.

During daylight, on the Moon, the eye would be constantly picking up the glare from the surrounding landscape. It would never have a chance of switching over to its "high sensitivity" range, and the stars would thus remain invisible. Only if the eye was shielded from all other light sources would the stars slowly appear in the black sky.

You can put this to the test quite easily by standing well back from the window in a brilliantly lit room one night, and seeing how many stars you can observe in the sky outside. Then remember that the light reflected from the walls around you is less than a hundredth of the glare that the lunar rocks would throw back.

This situation poses a pretty problem to the artist attempting to illustrate lunar scenes. Shall he put in the stars or not? After all, they are there and can be seen if one looks for them in the right way. Besides, everybody *expects* to see them in the picture. . . .

The Sun's corona would be invisible to the naked eye for the simple reason that it would be impossible to look anywhere near the Sun without dark glasses. If they were sufficiently opaque to make the Sun endurable, they would cut out the million-times-fainter corona altogether. It could, however, be seen without difficulty if one made an artificial eclipse by holding up a circular disc that exactly covered the Sun.

The errors and misunderstandings discussed in this article have ranged from the trivial to the subtle, and some of them have involved important principles. The lesson that can be learned from them all is this—before we can conquer space, we must not only have a clear picture of all the factors involved, but we must also empty our minds of preconceived ideas which may colour our conclusions. We don't want any future astronauts looking at each other with blanched faces and saying: "Someone should have thought of that. . . ."

PERTURBATION MANOEUVRES

By Derek F. Lawden, M.A.

SUMMARY

The calculation of the velocity increment induced in a space ship due to its attraction by a large moving body and without expenditure of fuel is explained. Such a "perturbation manoeuvre" is seen as a means of economizing in the fuel requirement of an interplanetary journey.

1. Introduction

A number of writers have suggested that the fuel requirements of a journey between the Earth and the other planets might be reduced by taking advantage of the attractions of various bodies of the solar system, but the method of calculating such perturbing effects and the economies to be expected do not appear to be widely known. In the next section we shall consider this problem of a space ship attracted by a moving body and will show how to obtain the resulting velocity increment induced in the ship.

2. General Problem

Let $\mathbf{v}_0$ be a vector denoting the velocity of the ship relative to the Sun when it is still at a great distance from the moving body (planet or moon) whose perturbing effect is required. If $\mathbf{V}$ is the velocity of the body, $\mathbf{u} = \mathbf{v}_0 - \mathbf{V}$ is the velocity of the ship as observed from the body. Fig. 1 indicates the

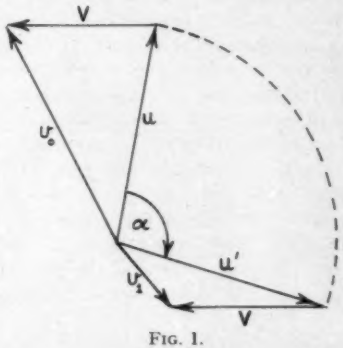


Fig. 1.

relationship between these vectors. An observer on the body will see the ship approach from infinity with velocity $\mathbf{u}$ and, provided we may neglect the effect of the attractions of other bodies including the Sun during the short time the perturbing body's field is effective, he will observe that the ship follows a hyperbolic trajectory with its focus at the centre of attraction, eventually receding to infinity with a velocity $\mathbf{u}'$ having the same magnitude as $\mathbf{u}$ but a direction differing from that of $\mathbf{u}$ by some angle α (see Fig. 1). $\mathbf{u}'$ is the velocity of the ship relative to the perturbing body. $\mathbf{v}_1 = \mathbf{u}' + \mathbf{V}$ is the velocity of the ship relative to the Sun. The difference between the velocity vectors $\mathbf{v}_0$ and $\mathbf{v}_1$ represents the perturbing effect.

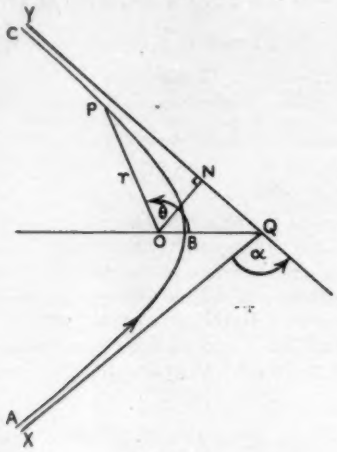


FIG. 2.

The magnitude of α will clearly depend upon the relative speed of approach **u** of the ship to the perturbing body and the closest distance of approach. If the latter is large, the body's attraction will have little effect and α will be very nearly zero. If, on the other hand, the ship approaches close to the surface of the body, α will be large and can take values up to a limit of 180°. The line of approach of the ship to the body can be varied, with negligible expenditure of fuel, by the application of small thrusts during the phase of the journey preceding the perturbation manoeuvre. The value taken by the angle α in the range (0°, 180°) can accordingly be regarded as under the control of the navigator. The sense of α (clockwise or anti-clockwise) may also be selected as required, since it depends only upon the side of the attracting body from which the approach is made. Given the value to be taken by α, the diagram of Fig. 1 can be drawn to scale in any particular case and the perturbation effect assessed. Alternatively, this diagram can be sketched and the problem solved by the use of trigonometry.

It remains to derive an equation exhibiting the dependence of α upon the relative speed and line of approach. Let O (Fig. 2) represent the centre of attraction and let ABC represent the track of the ship P as observed from the perturbing body. Let QX, QY be the asymptotes of this hyperbola and let α be that angle between them which represents the change in the direction of motion caused by the attracting body. Taking polar co-ordinates (r, θ) as shown, the equation of the hyperbola may be written.

$$\frac{a(e^2 - 1)}{r} = 1 + e\cos\theta, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where $a = \mathrm{BQ}$ and e is its eccentricity. When $r = \infty$, OP is parallel to QY

and hence $\theta = 90° + \frac{1}{2}\alpha$. Substituting this pair of values in equation (1), we find that

$$\operatorname{cosec} \tfrac{1}{2}\alpha = e. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (2)$$

The closest approach of the ship to O occurs at B. Let $OB = c$. Clearly, c must always be larger than the radius of the attracting body. When $\theta = 0$, $r = c$ and hence, by substitution of these values in equation (1), we obtain

$$\frac{a(e^2 - 1)}{c} = 1 + e,$$

$$\text{or} \quad e = 1 + \frac{c}{a}. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (3)$$

The speed v of the ship relative to O at any point of its hyperbolic trajectory is given by the energy equation

$$v^2 = \mu\left(\frac{2}{r} + \frac{1}{a}\right), \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (4)$$

where μ/r^2 is the attraction per unit mass at a distance r. If u is the relative speed of approach when the ship is at a great distance from O, $v = u$ when $r = \infty$. Hence

$$u^2 = \frac{\mu}{a}. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (5)$$

Elimination of a between equations (3) and (5) yields

$$e = 1 + \frac{cu^2}{\mu}, \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (6)$$

and hence, by equation (2),

$$\alpha = 2 \operatorname{cosec}^{-1}\left(1 + \frac{cu^2}{\mu}\right). \quad .. \quad .. \quad .. \quad .. \quad .. \quad (7)$$

Equation (7) determines α when the speed of approach u and the distance of closest approach c are known.

The line of approach may be specified for the navigator by the length of the perpendicular from O upon it. This is $ON = p$ in Fig. 2. Clearly

$$\begin{aligned} p &= (a + c) \cos \tfrac{1}{2}\alpha = ae \cos \tfrac{1}{2}\alpha \text{ (equation (3))} \\ &= a \cot \tfrac{1}{2}\alpha \text{ (equation (2))} \\ &= \frac{\mu}{u^2} \cot \tfrac{1}{2}\alpha \text{ (equation (5))}. \quad .. \quad .. \quad .. \quad .. \quad (8) \end{aligned}$$

Equation (8) permits the navigator to calculate the value of p he must aim for corresponding to any assigned manoeuvre.

3. Perturbation by the Moon

In this section we will calculate the economy to be expected from a perturbation manoeuvre involving the Moon. Let us suppose that a ship leaves a circular orbit about the Earth by applying a thrust which is only just sufficient to effect escape. The ship will recede along a parabolic arc and when at a

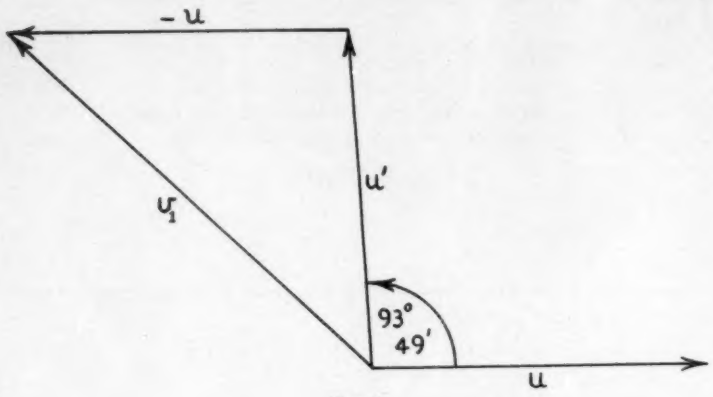


FIG. 3.

great distance from the Earth its velocity will be almost zero. Unless a further thrust is applied, or it is perturbed by another body, it will move around the Sun in the Earth's orbit. Suppose, however, that it is eventually attracted by the Moon. Its velocity relative to the Earth is zero and hence its velocity relative to the Moon is the same, apart from sense, as the velocity of this body in its orbit about the Earth, viz. $1{\cdot}02 \times 10^5$ cm./sec. The line of approach with this speed as seen by an observer on the Moon will depend upon the position of the Moon in her orbit at the instant we regard the ship as entering within her sphere of influence. By careful timing in the manoeuvre, the navigator will be able to choose this line of approach to suit his purposes. Let us suppose that he plans to graze the Moon's surface in order to take maximum advantage of her attraction. Then, in the notation of the previous section, c is equal to the radius of the Moon. Hence $c = 1{\cdot}74 \times 10^8$ cm. Also $u = 1{\cdot}02 \times 10^5$ cm/sec., $\mu = 4{\cdot}90 \times 10^{18}$ c.g.s. units. Substituting in equation (7), we find that $\alpha = 93{\cdot}49'$. $\mathbf{u}'$ makes this angle with the vector $\mathbf{u}$ as shown in Fig. 3. Adding the Moon's velocity (which is equal and opposite to $\mathbf{u}$) vectorially to $\mathbf{u}'$, we obtain the ship's velocity relative to the Earth at the termination of the perturbation manoeuvre, $\mathbf{v}_1$. A little trigonometry shows that the magnitude of $\mathbf{v}_1$ is $1{\cdot}49 \times 10^5$ cm./sec. At the commencement of the manoeuvre the ship had zero velocity relative to the Earth. The perturbation has accordingly resulted in a velocity increment of 1·49 km./sec. By choosing the time of take-off appropriately, this increment can be arranged to augment that component of the ship's velocity due to the motion of the Earth in its orbit or, alternatively, to act in the opposite sense. To reach the orbit of Mars, a velocity increment of 2·95 km./sec must be given to the ship after release from the Earth's field, whereas the orbit of Venus can be reached after a velocity decrement of 2·50 km./sec. It will be noted that about 50 per cent. of these velocity changes can be acquired by making use of the Moon's attraction with no expenditure of fuel. No violation of the law of conservation of energy is involved, since a gain in

energy of the ship is exactly compensated by a corresponding loss on the part of the Moon (which will hardly be aware of the deprivation !). In the case of Mars, much of the velocity increment required by the ship at the end of its journey along the Hohmann ellipse can similarly be made up by a perturbation manoeuvre based upon Deimos or Phobos.

It will be appreciated that the foregoing calculation has been of an approximate nature only. For one thing the fields of the Earth and Moon have been treated as though their spheres of influence are entirely separate, whereas in fact they will both be operative on the ship at all times. However, the results obtained may be accepted as a good guide to the magnitude of the effect to be expected.

4. Further Numerical Illustration

As a second example of the method, we will calculate the perturbing effect of Mars in the case of a ship which follows the Hohmann ellipse connecting the orbits of the Earth and Mars and chooses a line of approach to Mars which causes it to graze the surface of the planet. The velocity of the ship, as it approaches Mars, is less than that of the planet in its orbit by 2·65 km./sec. Its velocity relative to Mars is accordingly 2·65 km./sec in a direction opposite to that of the motion of Mars in its orbit. The radius of Mars is $3{\cdot}4 \times 10^8$ cm. In equation (7) we therefore put $u = 2{\cdot}65 \times 10^5$, $c = 3{\cdot}4 \times 10^8$, $\mu = 4{\cdot}30 \times 10^{19}$ and obtain $\alpha = 80°$. The relationship between the relative velocity of the ship to Mars before the perturbation **u** and afterwards **u′**, is shown in Fig. 4.

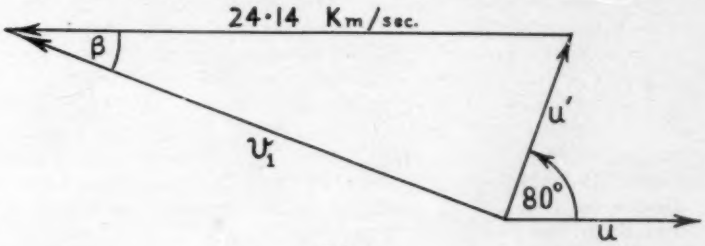


FIG. 4.

Adding vectorially to **u′** the velocity of Mars in its orbit (24·14 km./sec. in a direction opposite to that of **u**) we obtain the velocity $\mathbf{v}_1$ of the ship relative to the Sun at the termination of the manoeuvre. A little trigonometry proves that $\mathbf{v}_1$ has a magnitude of 23·82 km./sec. and makes an angle of $\beta = 6° 17'$ with the direction of the motion of Mars. This shows that there has been a net velocity increment of 2·33 km./sec due to the perturbation.

5. Conclusions and Recommendations

By judicious planning of a journey between two planets, taking advantage of the possible perturbing effects of the many asteroids, a considerable saving in fuel can almost certainly be effected. The manner in which maximum advantage may be taken of the attraction of any such body in the case of a particular

journey may be calculated by employing the technique for the discovery of optimal trajectories which has been described by the author elsewhere. This will be the subject of a future investigation. However, a series of numerical investigations of the type explained in this article would act as a very useful basis for this more theoretical research and such work is recommended to those interested in orbital computations.

SOME COMMENTS ON STRUGHOLD'S IDEAS ON MARTIAN VEGETATION

By A. E. Slater, M.A., M.R.C.S., L.R.C.P., F.R.Met.S.

Dr. Hubertus Strughold's most interesting book *The Green and Red Planet*, the American edition of which was reviewed by Mr. E. R. Nye in the January issue of this journal (page 58), has now been published in England by Messrs. Sidgwick and Jackson at 7s. 6d.—a mere fraction of its original price of 4 dollars. Since this is bound to increase its circulation, the time seems opportune for a few comments on Dr. Strughold's ideas which appear to be called for.

My reading of the purpose of the book is that it is not just a general review of the possibilities of life on Mars, but that the general aspect serves as a setting for a highly original suggestion which Strughold first propounded in the symposium *Space Medicine* (reviewed in *J.B.I.S.*, September, 1952, p. 239), but which Mr. Nye's review does not mention. The suggestion is that the Martian vegetation keeps within its tissues the oxygen it produces by photosynthesis* and then uses this oxygen for respiration, instead of taking it from the air, as earthly plants are able to do. Thus does Strughold dispose neatly of the argument that there cannot be life on Mars because oxygen is virtually absent from the atmosphere.

Strughold devotes the whole of his Chapter 7, "A Hidden Store of Oxygen," to this idea. But there is one point on which he seems to have gone astray, and by coincidence it comes on the same page as the one about ice crystals in air spaces which Mr. Nye criticized in his review.

On page 72 of the American edition, Strughold says that:—"On such a planet as Mars a plant presumably could produce no oxygen to speak of beyond its own needs, because of the limited supply of water and the reduced amount of energy available from sunlight. Therefore it would not be constantly increasing the hoard of free oxygen in the air, as our plants do. Although there would actually be enough oxygen within the vegetation to maintain life, no visible trace of it would be found in the atmosphere. And this is in fact the case on Mars."

Actually, the question whether the hoard of oxygen would increase has nothing to do with the strength of the sunlight, but would depend solely on whether the plant as a whole was growing or not. Strughold himself gives the

* *The process by which the energy of sunlight, trapped by the green chlorophyll, is used to build up organic substance out of carbon dioxide and water, giving off oxygen as a by-product.*

relevant chemical reactions earlier in his book. On page 14 the formula for photosynthesis is given:

$$6CO_2 + 6H_2O + \text{light energy} \longrightarrow C_6H_{12}O_6 + 6O_2$$

and on page 17 the formula for respiration:

$$C_6H_{12}O_2 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{energy}.$$

Thus, in photosynthesis 6 molecules of oxygen are liberated for every molecule of carbohydrate built up; while in respiration the same amount of oxygen, 6 molecules, is needed to oxidize the one molecule of carbohydrate—i.e. to burn up the fuel to provide the energy the plant needs in order to live.

If the plant is to grow, then more carbohydrate must be built up by photosynthesis than is burnt up by respiration, so that more oxygen must be liberated than is used up again, and the store of oxygen must necessarily increase. (If proteins or oils are built up, the proportions are slightly different, but the main argument is not affected.)

However, this process cannot go on indefinitely, unless the Martian plants are immortal. On the Earth, when plants die, they usually become oxidized, either in the bodies of animals, or by decaying where they fall, and it will be seen from the formulae that the surplus oxygen they have put into the air while growing will be exactly used up when the same amount of tissue decays by oxidation.

But not always. On the Earth, during past geological ages, a vast amount of vegetation has been buried under water in swamps, etc., before it had time to be oxidized by decay, and has turned into coal; and other organisms have similarly been buried unoxidized and turned into oil. The surplus oxygen, which might have been used to oxidize them but was not, must have remained in the atmosphere, and according to a theory widely held for many years, this explains why the Earth's atmosphere contains such a lot of oxygen. (The only plausible rival theory is that water molecules in the atmosphere are dissociated by light energy, the oxygen remaining in the air and the hydrogen flying off into space.)

Thus the virtual absence of oxygen in the atmosphere of Mars can be explained on the assumption that none of the vegetation has been buried unoxidized after death, possibly because of the scarcity of water; and incidentally it follows that future colonists will find no coal or oil below ground. But if we accept Strughold's suggestion, we still have to explain how surplus oxygen stored in the growing plants can be transferred to the dying ones to help them to decay. Are animals the answer? It seems to me that Strughold, having made such an ingenious suggestion, might well have followed it through to its logical conclusion.

Another question for which room might well have been found in a book on Martian vegetation concerns the changes in colour with the seasons. The main force of the classic argument in favour of life on Mars is not merely that the dusky areas are greenish, but that this colour changes in various regions into a wide variety of browns, reds, purples and yellows, covering the same range of hues to be found in different species of autumn leaves on the Earth. But this

argument obviously loses its force unless it can be shown that organisms containing green chlorophyll must necessarily change colour in this way. Yet I have searched through book after book on botanical physiology without finding a clue to this important question. Can some knowledgeable reader say where the answer is to be found? It is certainly not in Strughold's book.

However, the nature of this question, and its probable answer, have been somewhat changed by the modern idea that Martian vegetation may consist of something rather like the terrestrial lichens. These, too, undergo colour changes, but not in the same way as green plants, and therefore, possibly, for different reasons. The student of lichens will, however, likewise find himself baulked by the scarcity of literature on the subject. True, there are plenty of modern books on fungi, but each gives no more than a perfunctory page or two to lichens. The most recent English book entirely devoted to lichens is (or was) *Lichens* by Annie L. Smith, published in 1921 and long out of print.

Fortunately, lichen colour changes are discussed in the second edition of *The Atmospheres of the Earth and Planets* by Gerard P. Kuiper who, since he wrote in the first edition, has been chasing up several American scientists to give him more information about lichens, which will be found on pages 402-404 of the said second edition. He has also looked up a German book, *Biologie der Flechten*, by F. Tobler, but even that was published as long ago as 1925.

"The colours of lichens," Kuiper writes, "appear to be influenced by the intensity of the incident light and by the humidity . . . The same species (on the Earth) may be grey-green in dark places and bright yellow by higher sun or if found on rocks." And again: "Lichens exposed to strong sunlight may have shielding devices; a brown dye is found in certain species, possibly having this function." This gives us something to go on, but it all seems very tentative.

A further question, which seems to me to have been inadequately explained by writers on Martian vegetation, concerns the spectrum of lichens. In both editions of *The Atmospheres of the Earth and Planets*, on pages 338 and 363 respectively, Kuiper compares in Fig. 88 the spectra of higher plants and of lichens. The curves show the intensity of the reflection from them in different wave-lengths from red through infra-red. Higher plants give the characteristic curve of chlorophyll, but the curve for "algae, fungi, mosses and liverworts" is given as an absolutely straight line, except for a bit at one end, where it falls. But we are not given a curve for any specific lichen, which may, for all we know, differ from a straight line. Furthermore, it is said that the reflectivity of a green area on Mars was compared with that of the surrounding desert and the contrast, in each of the four different wave-lengths tried, was "nearly the same." But "nearly" is not "quite."

If the infra-red spectrum intensity curve of a lichen differs from a straight line in the same way as that of a Martian green area, then we have something to go on, even if it amounts to no more than saying that lichens are not excluded. But to give the impression that both are just straight lines makes the evidence quite unnecessarily negative.

Again, the colour of greenish lichens is presumably due to the chlorophyll in the algae which they contain, so it is hard to believe statements that their visible spectrum shows no sign of that of chlorophyll.

THE FIFTH INTERNATIONAL ASTRONAUTICAL CONGRESS

Innsbruck, 1954

The Fifth Congress of the International Astronautical Federation took place at the invitation of the *Österreichische Gesellschaft für Weltraumforschung* at Innsbruck, Austria, during the first week of August, 1954. All meetings and lectures were held in the light and airy University buildings, at whose entrance fluttered the flags of the participating nations. The atmosphere of the Congress was delightfully relaxed, a fact attributable to the ideal weather conditions which permitted the participants to appreciate to the full the impressive mountain scenery visible on all sides of this capital of the Austrian Tyrol.

Delegates representing Argentine, Austria, Denmark, Great Britain, Holland, Italy, Norway, South Africa, Sweden, Switzerland, United States, West Germany and Yugoslavia were present at the Congress. The smaller American rocket societies and the five new astronautical societies of America, Brazil Egypt, Japan and Spain, seeking membership of the IAF, were also represented. Dr. L. R. Shepherd and Mr. D. F. Lawden acted for the BIS, the latter also representing the South African Interplanetary Society who were unable to send their own delegate. Other BIS members who attended were Messrs. Burgess, Cleaver, Gatland and Strickson. M. Ananoff of France was present at all the delegate sessions though, as one of the founders of the IAF, it must have been particularly distressing for him to have to report the liquidation in 1953 of the French astronautical group. He hoped that this anomaly, that the founder country of the IAF had itself no astronautical society, would be removed very shortly.

The Congress was officially opened in the Great Hall of the University on Monday morning (August 2) welcoming speeches being delivered by Professor Hecht (IAF Vice-President) for the host society, the University Vice-Chancellor for the University and the Bürgermeister for the town of Innsbruck. Mr. F. C. Durant (IAF President) replied. Speeches were also forthcoming from the astronautical pioneers, Professor Oberth and Ing. Guido von Pirquet, the internationally recognized aerodynamicist, Professor T. von Karman, and the physicist, Professor Hans Thirring.

The first delegate session commenced on Monday afternoon with an introductory address by the President, Mr. F. C. Durant (ARS). All delegates then introduced themselves and reported upon the membership (Appendix A) and activities of their respective societies. Mr. Kaeppeler (G.f.W.), acting for the smaller American societies (Chicago and Pacific Rocket societies, Philadelphia Astronautical Society and the Reaction Research Society), announced that these societies had agreed to merge into the American Astronautical Federation (AAF) with a total membership estimated at nearly 1,000. They therefore wished to withdraw individually from the IAF in order that the newly-formed society might apply for membership at a later date. Their withdrawal was agreed unanimously. The question of back dues still outstanding from these societies was referred to the Finance Committee for consideration.

Dr. Gerlach then announced the findings of the Credentials Committee with

Social Evening. Sunday, August 1.

(Reading clockwise: A. V. Cleaver, L. R. Shepherd, Dr. Dryden, Prof. von Karman and sister, L. Gompertz, and Mrs. Tabanera.

regard to the five applicants for membership. High government officials and university professors constituted the main body of the membership (27) of the Egyptian society which had been in existence for three months. Its admission to the IAF was recommended and this recommendation was accepted unanimously. The Spanish society had resulted from the amalgamation of two groups, had a total membership of 62 and published a quarterly journal. Its application was also approved. The Japanese society included many highly qualified scientists amongst its members (151) and it was their intention to carry out research into problems of space-flight. The first two copies of a bulletin had already been published. The constitution of the society was not available and it was suggested that this society be accepted provisionally subject to the submission and approval of a translation of their constitution. This was agreed. The Brazilian society also appeared to possess a strongly scientific character, having several working teams conducting investigations into astronomical and other problems. Its application was approved. Also admitted to membership was the new American society, the American Astronautical Society (AAS). This society is not to be confused with the AAF referred to above.

The minutes of the Fourth Congress having been adopted, the Secretary's report was read. His budget for the coming year was announced to be $700.

The business for the day concluded with the re-election of the Finance Committee, who, meeting that evening, decided to recommend the acceptance of the Secretary's budget proposals for the coming year, with the reservation that the request for $85 to buy books for the archives be rejected, and that this sum be transferred instead to a sinking fund. It was suggested that books required for inclusion in the archives should be acquired by reviewing them in

Business Session. In the left hand foreground are Messrs. Gompertz and Romick of the A.R.S.

the proposed new journal, *Astronautical Acta* rather than by direct purchase. The committee also considered the question of the dues owed by the American societies which had withdrawn from the IAF and proposed that this matter be dealt with by the Secretary. As regards the allocation of the estimated expenses of $700 between the individual societies, the committee proposed the following as an equitable distribution having regard to the membership of the respective societies—ARS $280, BIS $250, GfW $80, the remaining $90 to be found by the remaining societies. These proposals were later ratified by the Congress of delegates.

The venue for the Sixth Congress was the first item which arose for consideration on Tuesday morning (August 3). The Italian society, having offered at Zurich to entertain a future Congress, had a prior claim, but it appeared that the Italian delegate had not received instructions from his Council to repeat the offer and it was therefore decided to accept the invitation made on behalf of the Danish society by their delegate Mr. Hansen. The next Congress was accordingly fixed for Copenhagen during the week August 21 to 27, 1955. The delegates from Spain and Argentine both intimated that their societies would be happy to entertain the Congress on some future occasion.

The Congress next proceeded to the election of its officers for the coming year. Mr. F. C. Durant, the retiring President, was nominated by the Swiss society for a second term of office. The GfW delegate seconding this nomination pointed out that previous Presidents had held office for terms longer than a year and said that his society felt strongly that in cases where a President had proved himself efficient, the maintenance of continuity which would result from his continuing in office was a strong argument in favour of his renomination. Mr. Gompertz said that his society, the ARS, wished to nominate Dr. Shepherd

Messrs. L. R. Shepherd and D. F. Lawden at "some corner of a foreign table that is for ever England."
(In the foreground is Ing. Tabanera).

for this office, in view of his outstanding contributions in many fields of astronautics. However, a number of other delegates rose to support the views expressed by the GfW delegate and Dr. Shepherd accordingly stated that, whereas he greatly appreciated the honour of being selected as the nominee of the ARS, he would prefer to decline this nomination. Mr. Haley (ARS President, IAF Vice-President) said that the ARS were strongly opposed in principle to the re-election of a President. In his experience there was a great danger of a clique gaining control of a society, with consequent bad effects on that society, should it become traditional for the President to be re-elected. However, in view of the fine record of Mr. Durant he would suggest that the ARS representative withdrew his nomination and so make Mr. Durant's nomination unanimous. This Mr. Gompertz proceeded to do and Mr. Durant was then elected unanimously. By a tradition of the IAF, Mr. E. B. Andersen, as President of the host society for the next Congress, was elected a Vice-President. Professor Tabanera was elected as the second Vice-President and Mr. Stemmer was re-elected as Secretary.

The possibility of forming astronautical societies in Australia, Belgium, Canada, Greece and India next arose for discussion. The Secretary said that he would contact an interested party in Belgium and try to stimulate the formation of a society in that country. The President was in touch with former members of the Canadian Rocket Society and would try to influence them to take the necessary steps. Dr. Shepherd suggested that a search through the list of BIS members might result in the discovery of a number of individuals interested in astronautics in all these countries. Professor Hecht then gave an account of his attempts to gain Russian support for this Congress. He had made contact with the Russians through the Austrian Society for Cultural

Messrs. Cleaver, Durant and Stemmer at the opening session in the University Hall. Monday, August 2.

Relations with the Soviets and had received an enquiry whether papers could be presented in Russian. Professor Hecht had replied that he thought there would be no objection, provided an interpreter was made available for translation into one of the languages of the Congress. Preprints of all papers to be read at the Congress had been sent to the Russians but, apart from the sending of an acknowledgement, no further action had been taken by them. Mr. Cleaver informed the Congress that Professor Fessenkov, while on a visit to England, had approached Mr. Clarke and had stated that there was great interest in space flight in Russia. Mr. Cleaver suggested that if the IAF were attempting to attract the Russians into the Federation, it might be useful to contact Professor Fessenkov.

The Astronautica Acta Committee met during the morning, and the chairman, Professor Hecht, submitted his report to the Congress during the afternoon session. It was recommended that a well-known publishing house be commissioned to publish and distribute this official journal of the IAF. Quotations from Springer, Oldenbourg and Pustet had been considered and it had been decided to ask Congress to accept the offer of Springer to publish a volume of four numbers and 192 pages at £3 per volume. This proposal was accepted unanimously and Professor Hecht was elected Editor-in-Chief. Material for the first two numbers would be selected from amongst the papers to be presented at this Congress.

Captain G. Partel (Italy) reported that the Committee on Astronautical Terms had completed work on a dictionary. The book embraced 1,300 terms, definitions of which were given in English, French, German and Italian. It was now in the press and would be available at a price of 500 lire per copy.

The existence of GfW and OGfW working groups carrying out investigations

into various problems of astronautics was announced by Mr. Kaeppeler. The President hoped that the example of these two societies would be followed by other societies and that the IAF would act as a reporting centre for the results obtained by such groups. This concluded the business transactions of the Congress.

The presentation of technical papers commenced on Thursday morning (August 5) in a lecture theatre of the University and continued until Saturday morning (August 7). The action of the OGfW in distributing preprints of all papers amongst participants prior to the Congress was of the greatest assistance to authors and audience alike. The former were able to reduce their remarks to a brief synopsis of the paper's contents and the latter arrived prepared with well conceived questions and contributions. Three papers were in the names of BIS members, viz. *"The Thermal Dissipation of Meteorites by Bumper Screens"* by Dr. Langton, *"Optimal Programming of Rocket Thrust Direction"* by Mr. Lawden and *"Two Aspects of the Time Element in Interplanetary Flight"* by Dr. Preston-Thomas. Dr. Langton's paper was read by Mr. Cleaver and that of Dr. Preston-Thomas by Dr. Shepherd. A complete list of titles will be found in Appendix B. Those papers which are not selected for publication in Astronautica Acts will be available as reprints. BIS members requiring a reprint of any paper are advised to communicate with the author directly.

In addition to the technical lecture sessions, all of which could be attended by the general public, a number of talks having a more popular appeal and a film show were included in the programme. An astronautical exhibition also attracted many visitors.

With a very full business and lecture programme, delegates were still able to find time to participate in the many social activities organized by the Austrian society and to enjoy a little of the incomparable scenery of the Tyrol. The traditional informal reunion of delegates took place on the Sunday evening (August 1) at the Breinösel Restaurant and, in an informal and cosmopolitan atmosphere, a spirit of friendly co-operation was engendered which persisted throughout the week. A cosmic ray station at the top of the Hafelekar mountain was visited on Tuesday evening (August 3) and the return by cable car at night, with the lights of Innsbruck twinkling far below, enabled the party to imagine itself already in space with the stars visible on all sides. Before tackling the technicalities of the Congress papers, delegates and their wives spent the whole of Wednesday (August 4) relaxing on a coach trip to Reutte and Garmisch in Bavaria. Even this day was not completely free from technicalities, however, for it included a tour around the powder metallurgical plant at Reutte. Throughout the week, wives of the delegates were able to participate in visits to places of interest in the district.

The Congress terminated on Saturday evening (August 7) with a reception of delegates and their wives by the Landes-Hauptmann of the Tyrol. This was followed by a dinner at which speeches were delivered by Professor Hecht and Mr. Durant and Professor Schütte announced that the Oberth Medal for the current year would be presented to Dr. Strughold for his work in the field of space medicine. Dancing and general festivities continued until midnight, concluding the highly successful Fifth Astronautical Congress in the same congenial atmosphere as that in which it had begun.

APPENDIX A

LIST OF I.A.F. MEMBER-SOCIETIES

		Membership at	
		4th Cong. (1954)	*5th Cong.* (1955)
Argentina.	Sociedad Argentina Interplanetaria ..	185	280
Austria.	Oesterreichische Gesellschaft für Weltraumforschung	122	110
Brazil.	Sociedade Interplanetaria Brasileira ..	—	164
Denmark.	Dansk Interplanetarisk Selskab	45	31
Egypt.	Egyptian Astronautical Society	—	27
Germany.	Gesellschaft für Weltraumforschung ..	714	803
Holland.	Nederlandse Vereniging voor Ruimtevaart	160	160
Italy.	Associazzioni Italiana Razzi	105	130
Japan.	Japanese Astronautical Society	—	151
Norway.	Norsk Interplanetarisk Selskap ..	Not known	39
Spain.	Agrupacion Astronautica Espanola ..	—	62
Sweden	Svenska Interplanetarisk Selskap ..	42	67
Switzerland.	Schweizerische Astronautische Arbeitsgemeinschaft	62	61
Union of South Africa.	South African Interplanetary Society ..	44	63
U.K.	British Interplanetary Society	2,250	2,521
U.S.A.	American Rocket Society	2,301	2,799
	American Astronautical Society ..	—	64
Yugoslavia.	Yugoslav Astronautical Society	65	58
	Total	6,095	7,590

APPENDIX B

LIST OF TECHNICAL PAPERS

THURSDAY, AUGUST, 5, 1954.

(*a*) H. Oberth (GfW, Feucht): "*Grundsätzliches zur Raumtaucher-Ausrüstung.*"

(*b*) Irene Sänger-Bredt (GfW, Courcelle sur Yvette): "*Die Erforschung der Initialvorgänge bei Verbrennungsprozessen.*"

(*c*) E. Sänger (GfW, Courcelle sur Yvette): "*Stationäre Kernverbrennung in Raketen.*"

(*d*) A. J. Zaehringer (ARS): "*Solid Propellants and Astronautics.*"

(*e*) K. A. Ehricke (ARS): "*Analysis of Orbital Systems.*"

(*f*) H. H. Kölle (GfW, Stuttgart): "*Der Einfluss der Auslegung der Turbopumpe auf die Flugleistungen einer Grossrakete.*"

(*g*) N. H. Langton (BIS, Leicester): "*The Thermal Dissipation of Meteorites by Bumper Screens.*"

(*h*) D. C. Romick (ARS): "*Basic Design Principles Applicable to Reaction-Propelled Space Vehicles.*"

(*i*) E. Stuhlinger (ARS, Huntsville): "*Possibilities of Electrical Spaceship Propulsion.*"

(*j*) H. J. Kaeppeler und M. E. Kübler (GfW, Stuttgart): "*Die Rückkehr von geflügelten Geräten von Aussenstationsbahnen.*"

(*k*) H. Preston-Thomas (BIS, Ottawa): "*Two Aspects of the Time Element in Interplanetary Flight.*"

FRIDAY, AUGUST 6, 1954.

(*a*) M. Vertregt (NVR, Den Haag): "*Calculation of Step Rockets.*"

(*b*) G. v. Pirquet (OeGfW, Wien): "*Zur Nomenklatur der Gewichtswerte von Stufenraketen.*"

(*c*) D. F. Lawden (BIS, Birmingham): "*Optimal Programming of Rocket Thrust Direction.*"

(*d*) J. M. J. Kooy (NVR, Breda): "*On Automatic Steering of Step Rockets.*"

(*e*) R. Engel (AEA, Cerva): "*Entwurfsverfahren für Höhenraketen mit Pressgasförderung.*"

(*f*) U. T. Boedewadt (AEA, Cerva): "*Über den Einfluss der Rekombination auf die Leistung von Flüssigkeitsraketen.*"

(*g*) H. B. Merrill (ARS/RCA, New York): "*Closed Circuit Television.*"

(*h*) R. Merten (GfW, Duisburg): "*Die elektrische Nachbildung der Bewegungsverhältnisse einer Aussenstation (Experimentalvortrag).*

(*i*) J. Eugster (SAA, Bern): "*Demonstration über den Nachweis der kosmischen Strahlung im menschlichen Körper.*"

(*j*) H. Strughold (ARS): "*Space Equivalent Conditions Within the Earth's Atmosphere—Psysiological Aspects.*"

(*k*) E. Fitzer (OeGfW, Wien): "*Die Entwicklung temperaturbeständiger Werkstoffe.*"

(*l*) R. Kieffer und F. Benesovsky (Reutte, Tirol): "*Hochwarmfeste Sinterwerkstoffe.*"

SATURDAY, AUGUST 7, 1954.

(*a*) E. Vassy (Paris): "*L'exploration de la haute atmosphère avec les engines autopropulse et le programme français de l'Année Geophysique Internationale* 1957-58.

(*b*) F. I. Ordway (ARS, Paris): "*Space Flight Activities in the U.S.A.*"

(*c*) G. A. Partel (AIR, Monfalcone): "*IAF: Utopia or Reality?*"

(*d*) R. Dyrgalla (SAI, Buenos Aires): "*Die Neo-Ideographie als Mittel zur Verständigung für künftige Beziehungen mit anderen Planeten.*"

(*e*) F. Cap (OeGfW, Innsbruck): "*Über Strömungsvorgänge, die mit einer Verbrennung gekoppelt sind.*"

(*f*) H. Ruppe (GfW, Berlin-Charlottenburg): "*Über aerodynamische Erwärmung kegelförmiger Flugkörper im Bereiche extrem hoher Mach-Zahlen.*"

NOTES AND NEWS

Radio Show Earls Court 1954

The 1954 Radio Show at Earls Court, London, featured a military rocket projectile and also a display illustrating a system of rocket telemetery.

This latter was an interesting stand which illustrated the radio transmission of information from airborne projectiles during flight.

The system described included a means for the reception of this transmission and the final production of a photographic record of the various quantities measured and includes calibrations with timing and instant of firing marks.

During the flight of a projectile it is necessary to have a continuous record of the values of certain quantities such as accelerations, pressures, temperatures, voltages and currents obtaining within the projectile itself.

The projectile is fitted with a radio sender to effect transmission of these values, the sender being installed in a convenient space within the body of the missile.

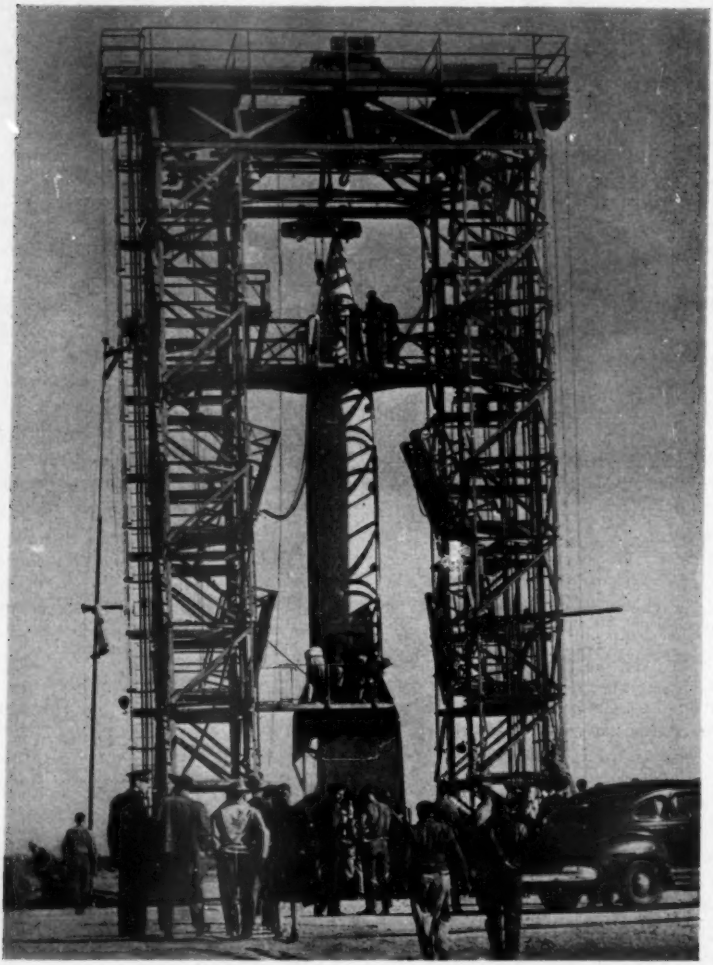
The various quantities to be measured are conveyed to "pickups" or transducers connected to the stator of a multi-contact switch. The quantities will be sampled by the rotor of this switch as it revolves at a pre-determined speed, the rotor being driven by a small electric motor.

One contact of the switch stator is used for the initiation of a synchronizing pulse which, after reception, is used in the ground equipment for the selection of the various channels in their correct sequence.

The switch rotor is connected indirectly to an oscillator in such a manner that electrical changes from each pickup or transducer vary the frequency of the oscillator. The output from this oscillator is then applied through a modulator to a power oscillator, and the resultant amplitude—modulated wave is radiated from aerials fitted to the projectile. The radiated wave thus consists of a time-multiplexed frequency modulated sub-carrier on an amplitude modulated carrier.

From the World's Press

It was with some surprise that we read that Prof. Bleksley is reported to have favoured the Moon as a military base. We had thought that, as with the military artificial satellite, this idea had received so many knock-outs in the past few years that it had finally been abandoned. But, according to the *Yorkshire*



V2 Rocket.

Technicians at the U.S. army ordnance proving ground at White Sands, New Mexico, check a V2 rocket shortly before firing.
The tower is a V2-type devised by the ordnance section for raising the rocket into its vertical firing position, and is moved away to a safe distance before the rocket shoots into the air.

Observer for 15th May, 1954, apparently not by Prof. Bleksley. He is quoted as having said that the Moon is probably the finest military base imaginable.

* * * * *

The Hindu of April 11, 1954, gave details of a speech by Dr. Bart. J. Bok, of Harvard, in which plans for a gigantic radar project were outlined. The idea is no less than to bounce radar signals off the planet Mars. The prime purpose of the venture is not, of course, to let any Martians know that Earthmen have mastered a certain amount of science and technology, but to obtain an accurate determination of the distance of Mars from the Earth, and accordingly of the Earth from the Sun. Dr. Bok anticipates that the Earth/Mars distance could be measured to within a few miles.

* * * * *

The centenary celebrations of the Society of Engineers, held in London during May, included the presentation of a paper by Sir Roy Fedden. *The Irish Times* for May 6, 1954, tells us that Sir Roy also believes that "provided it was politically sound to do so" voyages to the Moon and beyond would be possible within the next fifty years.

* * * * *

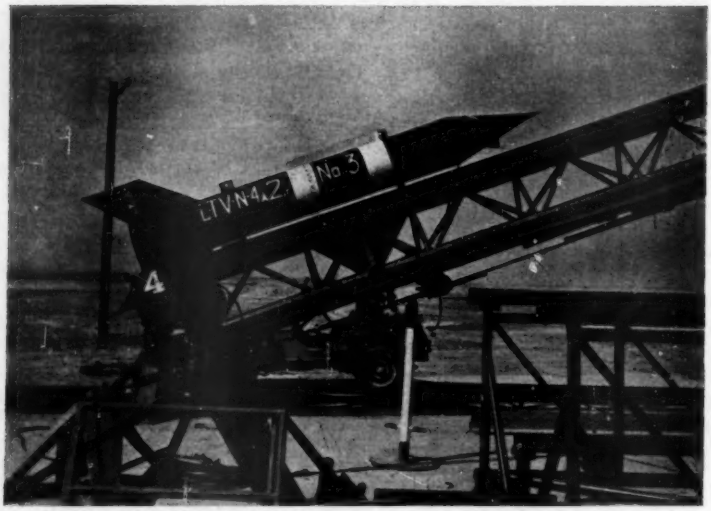
During the month of March a number of newspapers carried reports of the project of Dr. La Paz, Director of New Mexico University's Institute of Meteoritics. In conjunction with Dr. Clyde Tombaugh, the discoverer of Pluto, Dr. La Paz is organizing a search for natural earth satellites. A three-year survey of the equatorial plane regions is to be made photographically, the cameras sweeping the sky at the rate calculated to keep track with the motion of such satellites. If any exist they should then appear as dots on a background of star streaks. The search is sponsored by the U.S. Army Ordnance and Air Force and most of the work is to be done at White Sands.

The prime purpose of this search is to locate natural masses of materials moving in Earth satellite orbits which could be converted to space stations or refuelling stations. Once again we are not quite certain who is pulling who's leg. According to *The Montreal Gazette* March 31, 1954, Dr. La Paz is quoted as saying, "the nation first establishing a station in space will win the absolute control of the Earth." On the other hand, Dr. J. Blatt, reported in *Melbourne Argus*, February 16, 1954, has the right idea about space stations. He emphasized their use for astronomical and astrophysical research and the making of observations which are impossible from the bottom of the Earth's blanket of atmosphere. This theme was also stressed by a balanced feature article written by Dr. W. Hassock of the David Dunlap Observatory, which appeared in *The Toronto Globe*, May 1, 1954.

* * * *

Following the lead of Prof. Nesmayanov, other Russian scientists have been causing a flood of comments in the world's press by dropping diverse hints concerning Soviet aspirations towards space flight. Moscow Radio exhorted Soviet youth to become new interplanetary Columbuses—though we feel

A-4 taking off from "arena" test stand 7, Peenemünde. 1942.



U.S. Solid Propellant Booster Rocket on Launching Ramp.

A solid propellant booster rocket with a groundlevel thrust considerably in excess of that developed by the German V2 rocket which was flown successfully at the Naval Ordnance Test Station, Inyokern in 1949.
The rocket was designed for use in launching supersonic missiles, especially those relying on the ram-jet engine.

that someone made a definite *faux pas* there, because surely it was Overoceanski who discovered America! In view of the historical items recently encountered by a *Daily Express* special correspondent in the U.S.S.R., for example, the Russian inventors of radio, telegraphy, steam engines, etc., all many years before Marconi, Morse, James Watt and others, the forthcoming Soviet exhibition on the history of interplanetary flight which is to be organized by the astronavigation section of the Chkalov Central Aero Club should be fascinating. But we thought that the comments of the *New York Times*, March 25, 1954, *apropos* this East/West race to the Moon were perhaps a little overdone. "If the first man to get to the Moon is not a Soviet citizen, a historical injustice will be committed. As is well known, there was no Moon until the Soviets discovered it."

"Right, Bert, one diamond-shaped, cigar-shaped, boomerang shaped, fast moving, hovering flying saucer, ready when you are."

Reproduced by courtesy of the Editor, "Evening News."

* * * *

The cartoon (right) is prompted by a balloon seen by many thousands of people in London on July 7 and reported as a flying saucer of such shapes and sizes as to defy imagination.

EXPLORATION OF THE MOON

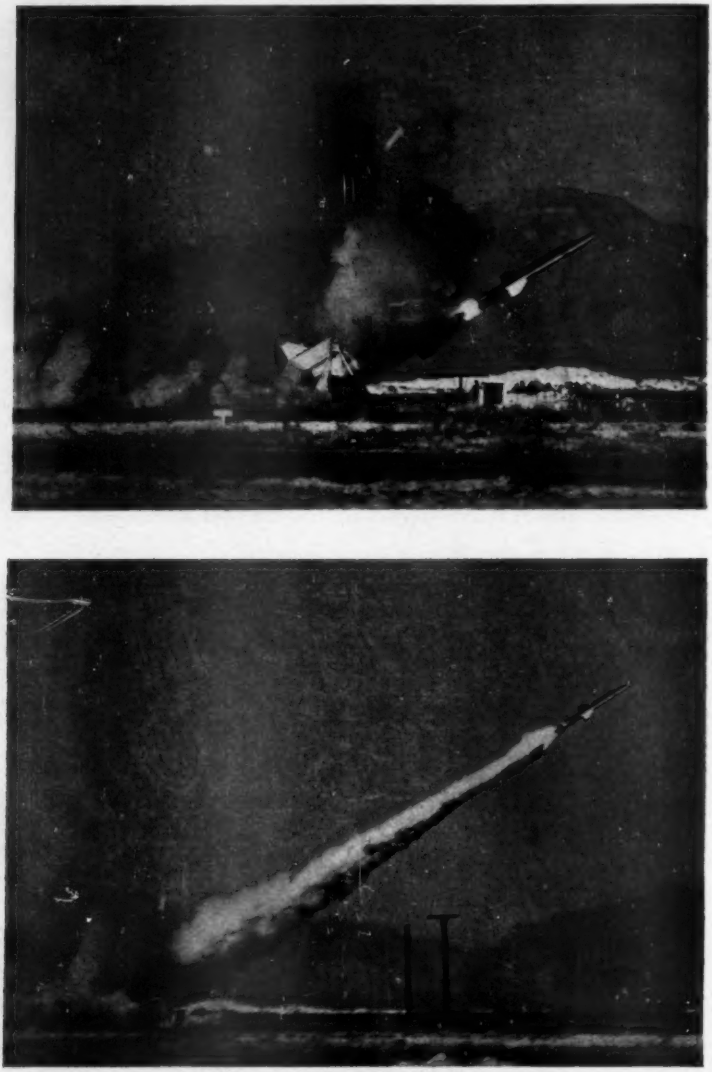
Illustrations by R.A.SMITH

Text by

ARTHUR C. CLARKE

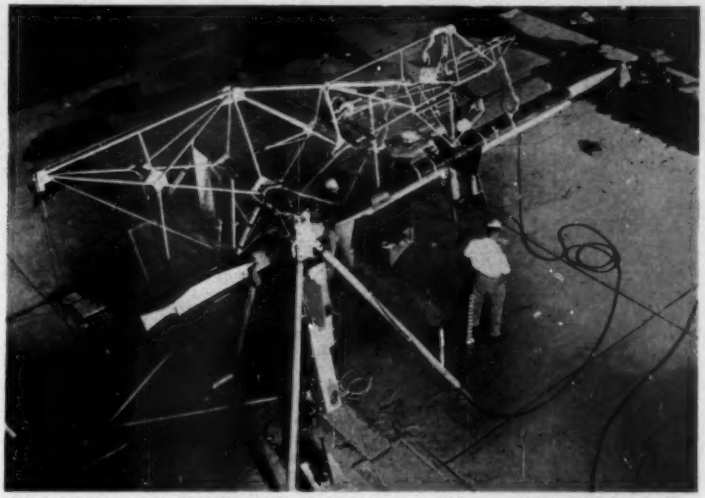
Step-by-step presentation with 45 full-page illustrations, eight in full colour, Cr. 4to 18/- net.

FREDERICK MULLER



BOEING GAPA guided Missile

These two pictures show a Boeing Airplane Company GAPA guided missile a split-second after it left its launching tower in a test at Alamogordo, New Mexico.



Boeing GAPA missile. Technicians prepare to hoist one of the GAPA missiles into firing position on its launching stand.

Boeing GAPA

These three pictures feature a Boeing GAPA (Ground-to-Air Pilotless Aircraft) guided missile, one of more than 100 supersonic test vehicles developed under a USAF contract. The programme which was aimed not at developing a single perfected missile but rather a family of missiles, both rocket and ram-jet on a purely research basis, was begun in 1945 and concluded in 1949. It provided valuable experience in the design of more advanced projects, such as the Boeing Bomarc, a pilotless interceptor powered by twin Marquart supersonic ram-jets and a rocket booster.

Although the contract was completed some years ago, photographs of the GAPA missiles have only recently been released. The largest of these test vehicles had a length of 22 ft. when fitted with an 8 ft. solid-propellant booster and reached speeds of more than 1,500 m.p.h.

* * * *

Provisional Scottish Branch

It is understood that the Scottish Branch Secretary has now been able to make arrangements for a room to be hired in Edinburgh at 25, Charlotte Square, for use as a Society meeting place in that town.

Meetings have been arranged on October 29 and November 26, 1954, January 28, February 25 and March 25, 1955, respectively, i.e. on the last Friday of each month.

Members who would like to take part in the activities of the Branch are invited to write to the Branch Secretary, P. H. Tanner, Glasgow Art Gallery Museum, Kelvingrove, Glasgow, C.3.

ABSTRACTS

Edited by J. HUMPHRIES

Abbreviations of titles of journals were given in the May, 1950 issue of the *Journal*, and addenda have appeared in subsequent issues. The following is a further addendum to the list:—

Aero. Res. Coun. Rept. & Mem.	Aeronautical Research Council Reports & Memoranda.
Calif. Inst. Tech., Jet Prop. Lab.	California Institute of Technology, Jet Propulsion Laboratory.
Chem. Tr. J.	Chemical Trade Journal.
Mass. Inst. Tech., Depts. Chem. & Chem. Engng., Div. Ind. Co-op.	Massachusetts Institute of Technology, Departments of Chemistry & Chemical Engineering, Division of Industrial Co-operation.
N.A.C.A.	National Advisory Council on Aeronautics.
Phil. Astr. Soc. Bull.	Philadelphia Astronautical Society Bulletin.
Princeton Univ. Aero. Engng. Lab.	Princeton University Aeronautical Engineering Laboratory.
Princeton Univ. Aero. Res. Lab.	Princeton University Aeronautical Research Laboratory.
Princeton Univ. Gugg. Jet Prop. Center.	Princeton University Guggenheim Jet Propulsion Center.
Radio Televis. News.	Radio & Television News.
Rev. Obras Publ.	Revista de Obras Públicas.
Riv. Mat. Univ. Paprm.	Rivista di Matematica dell'Università di Paprm.
Riv. Mil.	Rivista Militare.
U.S. Naval Ord. Test Sta.	U. S. Naval Ordnance Test Station.
U.S. Naval Res. Lab.	U.S. Naval Research Laboratory.

AIRCRAFT

(242) **Rocket fighter.** H. J. NOWARRA. *R.A.F. Flying Rev.*, **9**, (9), 11-13 (*June*, 1954). Development of the Messerschmidt 163.

(243) **Fifteen years of rocket aircraft.** H. KAISER. *Weltraumfahrt*, **5**, 82-83 (*July*, 1954). (*In German.*) Review of development, especially in Germany. Particular reference made to the first rocket aircraft, the He176 and the first turbo-jet aircraft, the He 178.

ASTRONAUTICS

See also abs. no. 282.

(244) **Astronautics: What must one think about the possibility of space travel?** T. MUR. *Rev. Obras Publ.*, **101**, 269-279 (*June*, 1953). (*In Spanish.*) Brief survey of astronautics: escape velocity, equations of rocket motion, mass ratio, the space station, lunar and interplanetary orbits, immediate possibilities, etc.

(245) **Take-off from satellite orbits.** K. A. EHRICKE. *J. Amer. Rocket Soc.*, **23**, 372-374 (*Nov.-Dec.*, 1953). Comments on paper by H. S. Tsien [*J. Amer. Rocket Soc.*, **23**, 233-236 (*July-Aug.*, 1953)].

(246) **Minimal rocket trajectories.** D. F. LAWDEN. *J. Amer. Rocket Soc.*, **23**, 360-367, 382 (*Nov.-Dec.*, 1953). The problem of the navigation of a rocket vehicle between two fixed terminals in space, in such a manner as to minimize the fuel expenditure, is analysed in a general fashion, account being taken of a gravitational field, variable in space and time. The motion is assumed to take place *in vacuo*. The transit time may or may not be specified. The solution trajectory is shown to comprise a number of null-thrust arcs, separated by junctions at which impulsive thrusts are applied. The conditions to be satisfied at these junctions are calculated. The theory is applied to the special case of the optimal transfer of a rocket between two coplanar elliptical orbits about a centre of attraction. (7 *refs.*)

(247) **Navigational calculations in space flight.** (Investigation of the effect of the precision of astronomical data). Pt. III. Satellite gravitational fields, orbital velocities, and elements of orbits. H. B. KETCHUM. *J. Space Flight*, **5** (10), 1-9 (*Dec.*, 1953).

(248) **Present impossibility of chemical propellant rockets.** G. PARTEL. *Alata*, **10** (2), 30 (*Feb.*, 1954). (*In Italian.*) Shows that performances obtainable with present exhaust velocities and mass ratios are less than those required for interplanetary journeys.

(249) **Reliability and spaceship design.** V. STORY. *J. Space Flight*, **6** (2), 2-4 (*Feb.*, 1954). (**4** *refs.*)

(250) **Space power and world peace.** T. E. PURDON. *Phil. Astro. Soc. Bull.*, **2**, 42-54 (*March*, 1954). (**8** *refs.*)

(251) **On the problem "The determination of the orbit by the vector of the velocity and the influence of its variation on the orbital elements."** H. G. L. KRAUSE. *Weltraumfahrt*, **5**, 48-51 (*April*, 1954). (*In German.*) Simplified derivation of equations obtained by Schütte, *Weltraumfahrt*, **4**, 98-107 (Oct., 1953) and **5**, 13-20 (*Jan.*, 1954). [For abs. see *J. Brit. Interplanet. Soc.*, **13**, 180, abs. no. 158 (*May*, 1954).] (**5** *refs.*)

(252) **Classification systems for space-flight.** E. SÄNGER. *Weltraumfahrt*, **5**, 60-61 (*April*, 1954). (*In German.*) Comparison of systems in use by various astronautical journals and proposed systems.

(253) **Day-dreams on the verge of space-flight.** I. SÄNGER-BREDT. *Weltraumfahrt*, **5**, 33-35 (*April*, 1954). (*In German.*) (**3** *refs.*)

(254) **Navigational problems in space flight. Pt. IV.** H. B. KETCHUM. *J. Space Flight*, **6** (6), 1-8 (*June*, 1954). Effects of friction in the Earth's atmosphere.

(255) **On the psychology of space-flight.** S. J. GERATHEWOHL. *Weltraumfahrt*, **5**, 65-68 (*July*, 1954). (*In German.*) An examination of various definitions of space and time.

ASTRONOMY

(256) **Formation of the lunar craters.** A. PALUZIE-BORRELL. *Urania*, **38**, 89-166 (*April-Sept.*, 1953). (*In Spanish.*) Detailed and critical review of the many theories advanced to explain crater formation. (**177** *refs.*)

(257) **The Lunar crater Atlas.** H. P. WILKINS. *Urania*, **38**, 87-88 (*April-Sept.*, 1953). (*In Spanish.*) Sketch and description of details of the crater.

(258) **Atmospheres of the planets.** A. OBULJEN. *Vasiona*, **1**, 39-40 (*Oct.-Dec.*, 1953). (*In Serbo-Croatian.*) Temperature ranges, pressures and composition of the planetary atmospheres.

(259) **The question of vegetation on Mars.** V. G. FESENKOV. *Dokl. Akud. Nauk., S.S.S.R.*, **94**, 197-198 (1954). (*In Russian.*)

(260) **Mars, planet of mystery.** N. J. BOWMAN. *J. Space Flight*, **6** (1), 1-7 (*Jan.*, 1954). Review of conditions on the surface of Mars. (**5** *refs.*)

(261) **Lunar observations.** H. P. WILKINS. *Urania*, **39**, 43-53 (*Jan.-March*, 1954). (*In Spanish.*) Account of details observed in and near various craters; illustrated by sketches.

(262) **Martian juvenation: the effect upon planetary conditions. Pt. I.** W. PROELL. *J. Space Flight*, **6** (5), 1-5 (*May*, 1954). Effects of delivering to Mars an atmosphere of 30 mm. pressure and 10^{20} grams water. (**2** *refs.*)

ATMOSPHERE

(263) **Unusual aerial phenomena.** J. A. HYNEK. *J. Opt. Soc. Amer.*, **43**, 311-314 (*April*, 1953). Reported phenomena which are not readily explained exhibit fairly well-defined patterns and are worthy of further study. One such pattern is that of the hovering nocturnal light.

(264) **Phantasmagoria or unusual observations in the atmosphere.** V. LIDDEL. *J. Opt. Soc. Amer.*, **43**, 314-317 (*April*, 1953). Reviews various types of "flying saucer" sightings and concludes that no evidence exists for any phenomena not explicable by standard physical concepts.

(265) **Terminology and nature of atmospheric shells.** G. W. WARES. *Jet Propulsion*, **24**, 33-35 (*Jan.-Feb.*, 1954). Description of the system of terminology in use by the Geophysics Research Directorate and which is based on the changes of temperature gradient with height.

CHEMISTRY

See also abs. nos. 330, 331 and 344.

(266) **Hydrogen peroxide. Pt. I.** W. C. SCHUMB, C. N. SATTERFIELD and R. L. WENTWORTH. *Mass. Inst. Tech., Depts. Chem. & Chem. Engng., Div. Ind. Co-op. Rept. No.* 42, 247 pp. (*Sept.*, 1953).

(267) **Hydrogen peroxide. Pt. 4.** W. C. SCHUMB, C. N. SATTERFIELD and R. L. WENTWORTH. *Mass. Inst. Tech., Depts. Chem. & Chem. Engng., Div. Ind. Co-op. Rept. No.* 45, 194 pp. (*Nov.*, 1953).

(268) **Mechanism of decomposition of concentrated hydrogen peroxide.** C. M. DREW and A. G. WHITTAKER. *U.S. Naval Ord. Test Sta. Tech. Memo. No.* 1602, 20 pp. (*Jan.*, 1954). Describes a method of measuring decomposition rates of concentrated hydrogen peroxide by following the weight loss of samples contained in quartz ampoules. Activation energy of 14·4 Kcal. is calculated from experimental results.

(269) **Kinetics of reaction between ammonia and oxygen.** H. WISE and M. F. FRECH. *Calif. Inst. Tech., Jet Prop. Lab., Prog. Rept. No.* 20-192, 18 pp. (*Jan.*, 1954).

MISCELLANEOUS

(270) **Rockets in Rockaway.** *"Missile Away!"* **2,** 18-20 (*March*, 1954). The story of Reaction Motors, Inc.

(271) **On the sixtieth birthday of Prof. Hermann Oberth.** H. K. KAISER. *Weltraumfahrt*, **5,** 53-56 (*April*, 1954). (*In German.*) Biography.

(272) **Rocket post and rocket stamps.** W. LEY. *Weltraumfahrt*, **5,** 35-41 (*April*, 1954). (*In German.*) A comprehensive illustrated history.

(273) **Experience with the application of hydrogen peroxide for production of power.** H. WALTER. *Jet Propulsion*, **24,** 166-171 (*May-June*, 1954). Review of German experience with rockets, V1 launching ramps, torpedoes and submarines. No accident occurred with any of the peroxide propulsion plants developed. (5 *refs.*)

PHYSICS

(274) **The motion of a body with variable mass.** T. MANACORDA. *Riv. Mat. Univ. Parma*, **3,** 361-373 (1952). (*In Italian.*) New derivation of equations of motion and application to a simple case.

(275) **Physical properties of concentrated nitric acid.** W. L. SIBBITT *et al. N.A.C.A. Tech. Note* 2970, 19 pp. (*June*, 1953). From a review of the literature and additional experimental measurements recommended values of the physical properties of white fuming nitric acid have been determined for the temperature range —35 to +300° F. Properties include thermal conductivity, dynamic viscosity, specific heat, density and vapour pressure. Except for vapour pressure all values are accurate to 5 per cent.

(276) **The design of helical atomizers.** G. D. MAXWELL. *Calif. Inst. Tech., Jet Prop. Lab., Prog. Rept. No.* 20-186. 39 pp. (*June* 3, 1953).

(277) **Vapor pressures of concentrated nitric acid solutions in the composition range 83 to 97 per cent. nitric acid, 0 to 6 per cent. nitrogen dioxide, 0 to 15 per cent. water, and in the temperature range 20° to 80°.** A. B. MCKEOWN and F. E. BELLES. *N.A.C.A. Res. Memo. E53 G08*, 22 pp. (*Sept.*, 1953).

(278) **Pressure gage connecting line, the effects on recorded rocket pressures produced by varying line dimensions and contents.** J. L. DUNKLE and W. A. HENDRICKS. *Hercules Powder Co., Allegany Ballistics Lab. Rept. No. ABL/B-10*, 18 pp. (*Sept.*, 1953.). Connecting lines should not be less than ¼ in. internal diameter nor more than 12 in. long. This length of air-filled line may be used for pressure rises of 42,000 p.s.i./sec.

(279) **The mechanics of film cooling.** E. L. KNUTH. *Calif. Inst. Tech., Jet Prop. Lab. Memo. No.* 20-85, 108 pp. (*Sept.*, 1953).

(280) **Experimental and mathematical techniques for determining the dynamic response of pressure gauges.** C. G. HYLKEMA and R. B. BOWERSOX. *Calif. Inst. Tech., Jet Prop. Lab., Memo. No.* 20-68, 27 pp. (*Oct.* 6, 1953).

(281) **Discussion on the luminescence theory of flames.** E. SÄNGER. *Weltraumfahrt* (1), 4-9 (*Jan.*, 1954). (*In German.*) (12 *refs.*)

(282) **On the decompression of a punctured pressurized cabin in vacuum flight.** S. T. DEMETRIADES. *Jet Propulsion*, **24**, 35-36 (*Jan.-Feb.*, 1954). The time which elapses before a dangerously low pressure is reached in a rigid cabin which is suddenly punctured when in space is a critical quantity in designing warning devices and counter-measures. An equation is derived giving a conservative estimate for this time as a function of initial and final pressure, area of hole and volume of cabin for a given gas at a fixed initial temperature. (1 *ref.*)

(283) **Comment on "Methods of flow measurement."** F. MINHAS. *Jet Propulsion*, **24**, 37-38 (*Jan.-Feb.*, 1954). For original paper by J. Grey and F. F. Liu see *J. Amer. Rocket Soc.*, **23**, 133-140 (*May-June*, 1953) [For abs. see *J. Brit. Interplanet. Soc.*, **13**, 118, abs. no. 119 (*March*, 1954).] Suggestion for flow-meter based on aerodynamic forces on an aerofoil section.

(284) **Flowmeter with a rapid response for liquid propellants.** M. BARRÈRE and A. MOUTET. *Rech. Aéronaut.*, (30), 15-21 (*March-April*, 1954). (*In French.*) This flowmeter is based on a venturi having a four-bladed rotor at the throat. The rotor speed is picked up optically by focussing a light on the rotor blades and the revolutions are counted electronically and indicated on a Speedomax counter. The accuracy is $\pm \frac{1}{2}$ per cent. and the instrument is linear up to 2 kg./sec.

(285) **In-flight measurement of liquid-oxygen temperature.** W. G. CASS. *Aero Dig.*, **68** (5), 38, 42 (*May*, 1954). Use of thermistors in Viking liquid oxygen tank.

(286) **Experimental investigation of heat-transfer and fluid-friction characteristics of white-fuming nitric acid.** B. A. REESE and R. W. GRAHAM. *N.A.C.A. Tech. Note No.* 3181, 46 pp. (*May*, 1954). A satisfactory equation for relating the Fanning friction coefficient with heat transfer and isothermal friction coefficient measured at the same Reynolds number is presented also an equation for correlating heat transfer results. Preliminary results presented for the regime of forced convection with nucleate boiling. (25 *refs.*)

(287) **Study of heat transfer to JP-4 jet fuel.** C. M. BEIGHLEY and L. E. DEAN. *Jet Propulsion*, **24**, 180-186 (*May-June*, 1954). Heat transfer and burn-out data were obtained in the nonboiling, nucleate boiling and film boiling regions for velocities from 3 to 40 ft./sec. and pressures from 30 to 500 p.s.i.a. The phenomenon of coking was studied visually and by use of coloured films. (17 *refs.*)

(288) **The ignition of fuel droplets descending through an oxidizing atmosphere.** H. L. WOOD and D. A. CHARVONIA. *Jet Propulsion*, **24**, 162-165 (*May-June*, 1954). Ignition studies with triethylamine, allylamine and cyclohexene descending in single droplets through the decomposition vapours of white fuming nitric acid are discussed. The parameters varied were acid vapour temperature (350° C. to 550° C.), fuel temperature (10° C. to 70° C.) and fuel-drop diameter (2.6 mm. to 4.2 mm.). Theoretical approaches to explain the observed ignition delays have not been successful. (14 *refs.*)

(289) **A simple method for calculation of gravitational components.** B. THÜRING. *Weltraumfahrt*, **5**, 69-72 (*July*, 1954). (*In German.*) Derivation of the gravitational components with respect to a rectangular system of co-ordinates for application to three-body problems.

(290) **On the burning of single drops of fuel in an oxidizing atmosphere.** M. GOLDSMITH and S. S. PENNER. *Jet Propulsion*, **24**, 245-251 (*July-Aug.*, 1954). A simplified model for the process of steady burning of a stationary droplet of fuel in an oxidizing atmosphere is examined. Explicit expressions are obtained for the burning rate of the droplet, the temperature at the flame front, and the radius of the combustion surface. (10 *refs.*)

(291) **Heat transfer and frictional pressure drop characteristics of white fuming nitric acid.** B. A. REESE and R. W. GRAHAM. *Jet Propulsion*, **24**, 228-233, 236 (*July-Aug.*, 1954). An equation for correlating heat transfer results is given; the pressure drop relations are similar to those found for pure liquids. Preliminary experiments in the local boiling region indicate that the heat transfer rate may be increased at least 30 per cent. over that obtained by forced convection. (13 *refs.*)

PROJECTILES

See also abs. no. 285.

(292) **The problem of intercontinental guided missiles.** M. A. d'ALESSANDRO. *Riv. Mil.*, 39 ff. (*July*, 1952). (*In Italian.*) [Also in *Mém. Artill. Franc.*, **28**, 237-251 (1954). (*In French*).] Derivation of formulae based on simplified assumptions.

(293) **The effect of variation of propellant density on rocket performance.** J. LORELL and A. HIBBS. *Calif. Inst. Tech., Jet Prop. Lab. Rept. No.* 20-66, 33 pp. (*July*, 1952).

(294) **Guided missile data recording.** J. B. WYNN and S. L. ACKERMANN. *Radio Televis. News*, **49** (2), 3-5, 28, 29 (*Feb.*, 1953).

(295) **U.S. guided missile progress in 1953.** N. J. BOWMAN. *J. Space Flight*, **6** (3), 1-10 (*March*, 1953). Comprehensive review of missiles and their propulsion units. Tabulated data. (2 *refs.*)

(296) **Some factors pertaining to the use of air breathing propulsion for the acceleration of high altitude sounding and other long range ballistic missiles.** J. W. LUECHT. *Soc. Automot. Engrs. Prep. No.* 145, 5 pp. (*Sept.*, 1953.)

(297) **Soviet A-A rocket development.** *Aviation Age*, **20** (4), 6-9 (*Oct.*, 1953). Installations are equipped mainly with developments of German missiles. An improved version of the Hs 117 and winged bombs powered by solid rocket motors developed from the Katyusha are in use.

(298) **The secret weapons of the U.S.S.R.** *Flugwelt*, **5**, 349-353 (*Nov.*, 1953) (*In German*). Brief outline of weapon development since 1924 and review of present-day weapons, location of factories, proving grounds and launching sites for long-range missiles.

(299) **Directed anti-aircraft and artillery missiles. Pt. 2.** A. AEPLI. *Flug. u. Tech.*, **15**, 278-80 (*Dec.*, 1953) (*In German*). Review of current developments and comparison of relative merits of bombing with directed missiles and with conventional aircraft-borne bombs.

(300) **Is aviation menaced by the prodigious development of guided missiles.** C. ROUGERON. *Science et Vie*, **84**, 496-504. (*Dec.*, 1953). (*In French.*) General review of present-day missiles.

(301) **8 cm. rocket for air-to-air and ground attack.** *Alata*, **10** (1), 9 (*Jan.*, 1954). (*In Italian.*) Illustrated description of an Oerlikon aircraft rocket: weight 10 kg., length 0·9 m., max. velocity 650 m./sec., warhead 1 kg., thrust about 600 kg. for about 0·8 sec.

(302) **Rocket powered anti-aircraft missiles in the U.S.S.R.** *Flugwelt*, **6**, 14-15 (*Jan.*, 1954) (*In German*). Range of solid propellant units has been increased to 55-65 km. The developed Wasserfall has a range of 100 km. and can be launched from mobile platforms on caterpillar tracks. All weapons are based on German ideas.

(303) **Kinematics of a vertical booster.** P. H. BLATZ. *Jet Propulsion*, **24**, 37 (*Jan.-Feb.*, 1954). A relationship between the mass ratio and burn-out velocity is established for simplified assumptions.

(304) **Boost-glide rockets.** A. M. JACKES. *Aero Dig.*, **68** (2), 34-35 (*Feb.*, 1954). Defines "energy height" and suggests use of air-breathing booster to attain high speed before using rocket stage with multi-stage projectiles.

(305) **Soviet rockets.** *Engrs. Dig.*, **15**, 89-90 (*March*, 1954). Estimate of probable present state of development. (1 ref.)

(306) **Up the wire.** N. WAGNER. *"Missile Away!"* **2**, 8-12 (*March*, 1954). Methods of flight safety in use at White Sands Proving Ground.

(307) **Ready for action.** *Ordnance*, **38**, 753-756 (*March-April*, 1954). Description and photos of Nike—first anti-aircraft guided missile to go into service in the U.S.

(308) **Foreign guided missile progress in 1953.** N. J. BOWMAN. *J. Space Flight*, **6**, (4), 1–8 (*April*, 1954). Comprehensive review of published literature. Emphasis on British and French missiles. Information tabulated.

309 **Vibrations of a rocket returning into the atmosphere.** G. LUDWIG. *Weltraumfahrt*, **5**, 43–48 (*April*, 1954). (*In German.*) Mathematical development.

(310) **A trip to Cocoa, Florida.** *Jet Propulsion*, **24**, 192-193 (*May-June*, 1954). Series of pictures of the Air Force Missile Test Centre.

(311) **Revision of the American missile policy.** *Alata*, **10** (6), 11-12 (*June*, 1954). (*In Italian.*) Possible developments on realization of Russian progress.

(312) **The new look in missiles.** *Ordnance*, **39**, 45-48 (*July-Aug.*, 1954). Information on and photos of Corporal, Honest John, Viking and Sparrow missiles.

(313) **Guided missile production.** S. M. SMOLENSKY. *Ordnance*, **39**, 64-67 (*July-Aug.*, 1954). Résumé of some of the problems encountered in research, development, manufacture and maintenance.

(314) **Problems of manoeuvrability in interception by missiles.** R. C. ABEL. *Aeronautics*, **31**, 20-22 (*Aug.*, 1954). Shows how radial accelerations of missile and target may be estimated.

ROCKET MOTORS

See also abs. nos. 348 and 349.

(315) **Experimental investigation of a light-weight rocket chamber.** J. E. DALGLEISH and A. O. TISCHLER. *N.A.C.A. Res. Memo. No. E52L19a*, (*Dec.*, 1952). Successful runs have been made with a jacketted combustion chamber fabricated by hydraulic forming from sheet steel.

(316) **Low frequency combustion stability of liquid rocket motors with different nozzles.** S.-I. CHENG. *Princeton Univ. Gugg. Jet Prop. Center Rept. No.* 244, 19 pp. (1953).

(317) **Contribution to the theory of photon rockets.** E. SÄNGER. *Ing. Arch.*, **21**, 213-226 (1953). (*In German.*) Proposes photon rocket in which particle reactions are used and photons are discharged after being suitably guided by reflectors. Specific consumption would be much lower than other types of rocket propulsion.

(318) **On the internal ballistics of the powder rocket.** W. GOHLKE. *Z. Ver. dtsch. Ing.* (*V.D.I.*), **95**, 519-525 (*June* 11, 1953). (*In German.*) Review article including description of solid propellant rockets, a derivation of the interior ballistic equations for tubular-grain rockets, and a discussion of the influence on burning rate and pressure of powder properties and motor parameters.

(319) **Concepts and theory of combustion instability.** S.-I. CHENG. *Princeton Univ. Aero. Engng. Lab. Rept. No.* 251, 24 pp. (*Oct.*, 1953).

(320) **High-frequency combustion instability in liquid propellant rocket with concentrated combustion and distributed time-lag.** S.-I. CHENG. *Princeton Univ. Aero. Res. Lab. Rept. No.* 246, 30 pp. (*Nov.*, 1953).

(321) **Determination of thrust alignment in rocket engines.** W. L. ROGERS. *J. Amer. Rocket Soc.*, **23**, 355-359 (*Nov.-Dec.*, 1953). As a result of deviations in the flight path of early missiles during launching, a program of thrust-alignment testing of full-scale motors was initiated at the Aerojet-General Corporation. Design and construction of the test facility are described. Procedures used and problems encountered are outlined, and methods used in reduction of data explained. Data from representative tests on both solid and liquid propellant motors are presented.

(322) **High-frequency combustion instability in solid propellant rockets.** S.-I. CHENG. *Jet Propulsion*, **24**, Pt. I, 27-32 (*Jan.-Feb.*, 1954). Pt. II, 102-109 (*March-April*, 1954). A theory is advanced based on the mechanism of self-excitation. The most unstable mode is shown to be the fundamental spiral mode. Rod grain is the most stable whilst tubular grain is the most unstable configuration. The stabilizing effect of inserting a non-burning solid rod into a tubular grain is verified by the theory. (7 *refs.*)

(323) **The correlation of interior ballistic data for solid propellants.** R. D. GECKLER and D. F. SPRENGER. *Jet Propulsion*, **24**, 22-26 (*Jan.-Feb.*, 1954). A self-consistent set of empirical equations is presented for describing concisely the most important performance parameters. These relate the propellant burning rate, propellant temperature, chamber pressure and area ratio so that a coherent set of correlations can be constructed from fragmentary data. Propellant variability is also examined and a number of relations among the variances of the parameters obtained. (3 *refs.*)

(324) **Excitation of oscillations by chemical reaction.** J. LORELL and H. WISE. *Jet Propulsion*, **24**, 110-111 (*March-April*, 1954). Considers the chemical kinetics of the combustion process as a source of excitation for pressure oscillations in a rocket motor. (13 *refs.*)

(325) **Nuclear reactors for rockets.** J. MCCARTHY. *Jet Propulsion*, **24**, 36-37 (*Jan.-Feb.*, 1954). To run a nuclear rocket at a temperature higher than the melting point of the fissionable material the chamber is spun on its axis thus keeping the material on the wall by centrifugal force. The working fluid, hydrogen, is injected through a porous wall and bubbles through the fissionable material.

(326) **Charge geometry and ballistic parameters for solid propellant rocket motors.** E. W. PRICE. *Jet Propulsion*, **24**, 16-21 (*Jan.-Feb.*, 1954). The dependence of four important parameters of internal ballistics of solid propellant rockets on charge and motor geometry is derived for the case of straight, side burning charges with linear variation of surface area relative to distance burned. The parameters are the ratio of burning surface area to nozzle throat area, burning surface area to internal channel area, nozzle throat area to internal channel area, and charge mass. Dimensionless variables are used and applications are given. (3 *refs.*)

(327) **Effect of wave propagation in feed lines on low-frequency rocket instability.** R. H. SABERSKY. *Jet Propulsion*, **24**, 172-174 (*May-June*, 1954). A simple rocket system is analysed for low-frequency instability. A numerical example illustrates that the effect of compressibility may become important for practical cases. It shows also that lengthening the lines may not always be beneficial and that, for a given time lag, the frequency may not change greatly with line length. (2 *refs.*)

(328) **The testing of rocket motors.** G. PARTEL. *Alata*, **10** (6), 31-32 (*June*, 1954), (*In Italian.*)

ROCKET PROPELLANTS

See also abs. nos. 273, 288, 290 and 348.

(329) **Rapid method for calculating the theoretical performance of rocket propellants.** U. T. BOEDEWADT. *Off. Nat. d'Études* and *de Rech. Aéronaut. Note Tech.* 15. (*In French.*) Interpolation method for deducing with the aid of extensive tabulations of internal energies of various mixtures the specific impulses, temperatures etc. of propellants containing only *C*, *H* and *O* at a combustion pressure of 16 kg./cm.^{2}

(330) **Analytical procedures for rocket propellants. IV, Hydrazine.** J. D. CLARK. *U.S. Naval Air Rocket Test Station Rept. No.* 9, 9 pp., (1951). Various methods for the determination of N_2H_4 and contained NH_3 and H_2O are discussed.

(331) **Analytical procedures for rocket propellants. V. Mixed butyl mercaptans.** J. D. CLARK. *U.S. Naval Air Rocket Test Station Rept. No.* 11, 4 pp. (1951). The assay of butyl mercaptan isomers mixed with propyl, amyl and higher mercaptans is discussed.

(332) **Compressibility measurements of some rocket engine propellants.** A. A. KOVITZ and K. R. STEHLING. *Bell Aircraft Corp. Rept. No.* 56-982-013, 22 pp. (*Sept.* 15, 1952). (5 *refs.*)

(333) **The calculated performance of ethyl alcohol—water mixtures as rocket fuels with liquid oxygen.** A. B. P. BEETON. *Aero. Res. Counc. Rept. & Mem.* 2816 8 pp. (1953). Calculated values of specific impulses and temperatures.

(334) **New rocket motors' fuels.** *Chem. Tr. J.*, **133**, 508 (*Aug.* 28, 1953). Description of D.H. Super Sprite.

(335) **Application of an electro-optical two-color pyrometer to measurement of flame temperature for liquid oxygen—hydrocarbon propellant combination.** M. F. HEIDMANN and R. J. PRIEM. *N.A.C.A. Tech. Note No.* 3033, 39 pp. (*Oct.*, 1953). Measurements made in an open-tube combustor during normal and oscillatory combustion showed sporadic temperature variations up to 1000° R and emissivity variations of 10 to 1.

(336) **A short-cut method for calculating the performance of fuels containing carbon, hydrogen, oxygen and nitrogen with nitric acid, liquid oxygen or ammonium nitrate.** S. A. JOHNSTON. *Calif. Inst. Tech., Jet Prop. Lab., Prog. Rept. No.* 20-202, 42 pp. (*Nov.*, 1953).

(337) **Compressibility studies of rocket propellants.** K. R. STEHLING and A. A. KOVITZ. *J. Amer. Rocket Soc.*, **23**, 374 (*Nov.-Dec.*, 1953). Comments on paper by G. G. Kretschmar [*J. Amer. Rocket Soc.*, **23**, 82 (*March-April*, 1953)]. Authors obtained speeds of sound in various propellants comparable with those measured by Kretschmar.

(338) **Thermodynamics of the exhaust gases of atomic missiles.** I. SÄNGER-BREDT. *Z. Naturforsch.*, **8**, 796-804 (*Dec.*, 1953). (*In German.*) General theory with performance figures for hydrogen.

(339) **Erosive burning of some composite solid propellants.** L. GREEN. *Jet Propulsion*, **24**, 9-15, 26 (*Jan.-Feb.*, 1954). Experimental data are reported and discussed. It is found that the erosive effect is greater in slow-burning propellants than in fast-burning ones. The existence of an apparent "threshold velocity for erosion" is tentatively attributed to the failure of the one-dimensional idealization to represent the true flow-conditions obtaining at the fore end of the grain. (14 *refs.*)

(340) **Ethylene oxide as a monopropellant.** W. C. ROBISON. *Jet Propulsion*, **24**, 111-112 (*March-April*, 1954). Performance figures. (1 *ref.*)

(341) **The isothermal compressibilities of some rocket propellant liquids, and the ratios of the two specific heats.** G. G. KRETSCHMAR. *Jet Propulsion*, **24**, 175-179, 186 (*May-June*, 1954). From sound velocity and density measurements the compressibilities and specific heat ratios have been calculated for hydrazine, W.F.N.A., JP-3 and JP-4. Velocity of sound was determined by means of an ultrasonic interferometer. (12 *refs.*)

(342) **Propellants for rockets and space ships.** J. G. TSCHINKEL. *Chem. Engng. News*, **32**, 2582-2587 (*June* 28, 1954). General review. (4 *refs.*)

(343) **Unstable burning of solid propellants.** L. GREEN. *Jet Propulsion*, **24**, 252-253 (*July-Aug.*, 1954). Suggests that burning stability may be influenced by the design of grain-support traps. (5 *refs.*)

(344) **The toxicity and health hazards of rocket propellants.** S. KROP. *Jet Propulsion*, 24, 223-227, 236 (*July-Aug.*, 1954). Deals with ammonia, aniline, alcohols (ethyl, furfuryl, methyl), hydrazine, JP-4, hydrogen peroxide, liquid oxygen and red fuming nitric acid. (17 *refs.*)

ROCKET PROPULSION

(345) **Wheeled propulsion and rocket propulsion.** E. SÄNGER. *Z. angew. Math. Phys.*, **5**, 164-167 (1954). (*In German.*) The propulsive efficiency of wheeled propulsion falls rapidly with increasing velocity so that for high speeds rocket propulsion is superior.

(346) **Rocket development.** H. N. TOFTOY. *Ordnance*, **38**, 591-594 (*Jan.-Feb.*, 1954). General review.

(347) **Rocket research for wings.** *Aero. Dig.*, **68** (2), 27 (*Feb.*, 1954). Use of rocket-propelled models by Lockheed to test wing structures in supersonic region.

(348) **The 8th A.R.S. National Convention: a technical summary.** J. E. SCOTT, G. B. MATTHEWS and A. A. KOVITZ. *Jet Propulsion*, **24**, 120-122 (*March-April*, 1954). Summaries of papers delivered.

(349) **Rockets today and tomorrow.** H. GARTMANN. *Weltraumfahrt*, **5**, 73-79 (*July*, 1954). (*In German.*) General review of rocket development up to present time and discussion of the possible trend of specific consumption of various types of unit. Present-day rocket missiles and their performances are tabulated. (15 *refs.*)

REVIEWS

The Young Traveller in Space

(By A. C. Clarke, Phoenix House Ltd., London, 72 pp. 7s. 6d. net)

The best way of overcoming scepticism towards interplanetary travel is to condition the youth of the country to the idea. This process must not be in the form of flights of fantasy, but more concerned with basic facts. Here then is a book with just such a purpose. Mr. Clarke presents to the adult of to-morrow the principles, and necessity, of the space travel of to-morrow.

The book begins with a history of the rocket, but fortunately this has been kept short, and the bulk of the book devoted to the more "meaty" problems of space-flight. Part of the book endeavours to educate the child on some elementary laws of nature—without him really knowing that he is learning! Consequently Father can expect some pretty close questioning if his son has an engineering turn of mind.

The youngster is transported, as a passenger, from earth to moon—with some very vivid impressions obtained at the transit station. He is then taken on a "mystery tour" in a lunar bus, which he is sure to find exciting. These trips are preceded by a trip on a V2, but fortunately Mr. Clarke does not describe the rather shattering journey's end.

The principles of reaction are (almost !) explained in Chapter 3, but it may be that the reader will not appreciate what is written there; however, it is very easy to criticize someone who sets himself such a difficult task—indeed it is difficult enough (if not in some cases impossible) to convince an adult of these principles. More success is met with when explaining what is meant by weight and mass—something which is not fully understood by some engineers! Here also the reader is given a peep into the future, with such things as atomic and electronic propulsion—what child would ever imagine any connection between T.V. and rocket motor propulsion?

The economic and social advantages of satellite stations and space-travel are outlined, and makes very interesting reading; fortunately the much-publicized military uses are not gone into, although at one point it looked as if this topic would be discussed. Any secondary school child will, I am sure, thoroughly enjoy reading this book—that is, after Dad has finished with it ! E. J. COLE.

Model Jets and Rockets for Boys

(By Raymond F. Yates. T. Werner Laurie Ltd., London. 115 pages, 49 illustrations. 8s. 6d.)

As its title indicates, this book is primarily intended for the young reader. It is especially directed towards the youngster who aspires to working models of aeroplanes and boats, and attempts to give such a reader a little of the background and working principles of some of the propulsive devices he might use.

The first chapter is exclusively concerned with the history of the rocket motor. This is dealt with quite comprehensively, and the few mistakes which have crept in do not seriously detract from the overall picture presented.

The second chapter deals with the working principles of the rocket motor, pulse jet, ram-jet and turbo-jet. A number of inaccuracies and misconceptions are immediately apparent and some of the most important characteristics of the different methods of propulsion are inadequately explained. This chapter ends with descriptions of a number of model pulse jet and rocket engines which have been made or are on the market, and it is obvious that the author is on firmer ground when discussing these, than when trying to explain their basic principles.

The remaining four chapters, which occupy the greater part of the book, are concerned with the application of these models and a number of hints and tips for operating them. Descriptions of a number of model aeroplanes, boats and cars are given, together with many items of practical advice undoubtedly based on the author's own experience. The youthful model maker will certainly find these chapters most interesting.

Given in one of these chapters is a word of warning for youthful experimenters which the reviewer feels is worthwhile repeating. All fuel burning devices, especially rockets, even in model form, are potentially dangerous when mishandled. Professional experimenters take very elaborate precautions against accidents since they are usually working with novel, relatively untried and undeveloped devices. Model enthusiasts cannot take quite the same precautions, but they can safeguard themselves if they follow to the letter the

instructions given by the manufacturers. If they feel that they have to go one better than the manufacturer and experiment themselves, then they should only do so if they know exactly what they are doing, and are certain they have taken every precaution against possible mishaps. W. N. NEAT.

The History of Astronomy

(By Giorgio Abetti. Translated from the Italian by Betty Burr Abetti. 345 pp. Sidgwick & Jackson, London. 25s.)

This book, written by the Director of the Arcetri Observatory and with a foreword by the Astronomer Royal, traces the history of astronomy from its dim beginnings, thousands of years ago, up to modern times. It is divided into three main sections—"From the Beginning to Copernicus," "Reformation of Astronomy" and "The Modern Era"—and is one of the most detailed general histories that has yet appeared. There are also some excellent illustrations, ranging from pictures of Galileo and Copernicus up to photographs taken with the 200-inch Hale reflector. The presentation and type are good, and there are few actual misprints, though one or two have crept in—for instance, the dates of Schröter's birth and death are wrongly given in the Index.

Unfortunately, the book in its present form is ruined by the inferior translation. The style is clumsy, and makes for difficult reading; many sentences are almost impossible to understand, and there are also cases of misused words (for instance, "alternatively" is used instead of "alternately"). This is a great pity, as the book is crammed with information, some of which is not readily available elsewhere.

The book is worthy of better treatment than this, and it is to be hoped that a second English edition will appear, with a new translation. Until this has been done, however, the book is unlikely to become as popular as other works of similar type. P. MOORE.

CORRESPONDENCE

The Solar Battery

SIR,

On April 25 Bell Telephone Laboratories announced a new device for the direct conversion of radiation into electricity[1] which is destined to play a most important part in the interplanetary field. The discovery arose out of intensive research in the field of semi-conductors which had the objective of improving and developing transistors.

The Bell solar battery consists of a number of thin plates of extremely pure silicon in the form of single crystals. One surface of each plate has been modified by the diffusion into it of a very small amount of boron. When these plates are exposed to sunlight they develop a potential difference of 0.5 volts across these faces, and a current of 17 milliamps per sq. cm. can be extracted by suitable electrical connections. This corresponds to the development of $8{\cdot}5 \times 10^{-3}$ watts per sq. cm., which is six per cent. of the total radiant energy

falling on the surface. Improvements are expected to bring this up to ten per cent., and this limit is set because the battery is only sensitive to a part of the spectrum, which is converted to electricity at very high efficiency. The battery itself is not used up in any way, and has no moving parts to wear out. It should, in theory, last for ever.

Eight of the small plates connected in series were used in a demonstration to provide power for a short wave radio transmission of speech, and Bell Telephone envisage applications as a power source for rural telephone lines in America. By the time an artificial satellite such as the M.O.U.S.E. is available, we can reasonably expect that Bell Telephones will be in a position to supply a power source which will consist simply of a surface exposed to the sun, generating electricity with a reliability which may well exceed that of the electronic components that use it.

This development demonstrates beautifully the way in which "scientific" prediction breaks down. Thus it is easy to work out[2] just how a solar energy converter will operate via thermal energy. But along comes a discovery in an entirely unrelated field which permits the direct conversion of radiation to electricity at high efficiency without violating the laws of thermodynamics, and without all the complex of mirrors, boilers, turbo-generators, etc.

Once again the scientist is one step ahead of even the science-fiction writers. I wonder how long it will take the "mercury boiler" to disappear from S.F. (and near S.F.) to be replaced by the direct solar converter.

C. A. Cross.

Northwich, Cheshire.

REFERENCES

(1) "Experimental Solar Battery," *The Engineer*, June 4, 1954, p. 834 (see also *Chemical Engineering News*, May 3, 1954, p. 1768).
(2) "The Fundamental Basis of Power Generation in a Satellite Vehicle," C. A. Cross, *J.B.I.S.*, Vol. 11 (3), 117.

A Famous Russian Encyclopaedia on Astronautics

Sir,

I would like to make a few remarks about the article on Professor Rynin's encyclopaedia in your July, 1954 issue. I own a complete set of this work which I received from Prof. Rynin directly, "issue" for "issue" as it was being printed. I believe that my set is the only one in the United States but there must be others outside the Iron Curtain, or at least very close to it on the other side. I do know that a set was mailed to the Prussian State Library, adjacent to Berlin University on *Unter den Linden*. The building, or what's left of it, is now in the Russian sector of Berlin but I happen to know that large portions of the library were "evacuated" when the big bombing raids started.

I believe that another set was in the Library of the German Army (*Bibliothek für Wehrwissenschaften*) also located within easy walking distance of Berlin University. Everything I said about the Prussian State Library applies here too, except that in the case of the Army's Library I know that the "evacuated portion" of the books were moved to West Germany.

I remember that Prof. Rynin wrote me at the time that he also mailed sets of his work to Professor Oberth "and to Vienna," the latter meaning either Dr. Franz von Hoefft (who now lives in Linz) or Baron von Pirquet; possibly both. I knew that he had sent one to Robert Esnault-Pelterie. I had a second but incomplete set, received from Dr. Yakov I. Perelman, which I passed on to a young and enthusiastic member of the *VfR* who intended to become the society's librarian. I don't know what happened to it.

It may interest you to learn that my correspondence with Professor Rynin was in English. At first he wrote me in German but these were very short postcards. One of his former pupils then told me that Rynin could write English far better than German, whereupon our correspondence became a little more articulate; but not much.

As for the missing first "issue" of your set I agree with Mr. G. V. E. Thompson that *if* one issue has to be missing it might as well be the first. It is merely a survey of folklore, fairy tales and legends, religious or otherwise, which involve flying into the sky. As a matter of fact it is poorly done, the same ground has been covered a little later much more thoroughly and with far better understanding by Dr. Berthold Laufer in his book *The Prehistory* of *Aviation* (Chicago). Prof. Rynin, I suspect, wanted to show that people have "always" dreamed about space travel. In reality, of course, they merely dreamed about flying.

One interesting point, however, is that this first issue is far superior to all the rest as a typographical work of art. It is lavishly illustrated, the pictures are well reproduced and light coated stock is used throughout. When this book arrived Prof. Oberth happened to be in Berlin and we looked at it together. I remember Oberth's remark that he could not consider it a contribution to science but that he was going to show it to his colleagues in Rumania, "the Rumanians couldn't do such a job of printing in a hundred years."

Some biographical material about Rynin, by his own hand, is printed as an introduction to his chapter in Brügel's *Männer der Rakete* (1932), Rynin's chapter in this book is almost the only piece by him which ever appeared in a language other than Russian. In 1944 I happened to talk to a Russian refugee in New York and in the course of the conversation Rynin's name was mentioned. The Russian told me that he had read of Rynin's death "recently" in the local Russian daily newspaper. But since he was not sure about the first name and the patronymic I accepted the assertion with caution, the death notice may not have referred to Nikolai Alekseevitch or to another person with the same family name. Immediately after the war I tried to find out by writing two letters (in Russian) to Rynin and to Dr. Perelman. I thought that, in case Rynin was dead, his successor at the Institute would inform me so. And Dr. Perelman would certainly know. The letter addressed to Rynin found no response whatever while the letter to Dr. Perelman was returned with a remark in handwriting (not P's handwriting) "this must be another Yakov Isidorovitch."

C'est tout!

WILLY LEY.

Jackson Heights, N.Y., U.S.A.

Centrifugal and Centripetal Force

SIR,

Mr. S. W. Greenwood and Mr. D. F. Lawden are perhaps both right (*J.B.I.S.*, Jan. and May, 1954).

(1) A body with the mass m, describing a circle of the radius r and with a constant velocity v, must in some way be acted upon by a *real* force F directed towards the centre, and being

$$F = \frac{mv^2}{r}$$

The force F is called the *centripetal force*. There will also be a *real centrifugal force*, acting not upon the body, but upon the centre. Let, in the case of a particle of the rim of a flywheel, F represent the centripetal force. Then, upon the axle of the flywheel acts a centrifugal force, equal to, and oppositely directed to, F. The resultant of all centrifugal forces $-F$ acting upon the axle, will, if the flywheel is balanced, be zero.

If the velocity v increases so much that the centripetal force required by the given orbit of the particle, exceeds the molecular forces, then the flywheel must break.

So much about the "flywheel case."

In the case of a satellite the centripetal force is simply represented by the gravitational force. The situation can be explained in this way: The satellite has a velocity just so great that the gravitational force makes it fall *continuously* down to the orbit line. *The satellite is therefore incessantly in the first (infinitesimal) phase of a free fall from the given niveau towards the centre of the earth.* Only one force, the gravitational (=centripetal) force, acts on the satellite. In the case of the 24-hour orbit this "free fall situation" is indeed a little curious —if studied from the earth.

(2) If we use the

$$\textit{formula } F = \frac{mv^2}{r}$$

and write the

$$\textit{equation } F - \frac{mv^2}{r} = 0$$

we have introduced a *fictitious centrifugal force* $\frac{mv^2}{r}$ "acting" on the body. This fictitious force can help us when studying special problems of equilibrium (d'Alemberts principle). It is this fictitious (but sometimes very useful) centrifugal force which is responsible for all the misunderstanding between "the centrifugalists" and "the non-centrifugalists."

Perhaps the whole problem is of more academic than technical interest!

GUNNAR OXAAL.

Oslo, Norway.

Annual Report

of the

British Interplanetary Society

Limited (by Guarantee)

NINTH ANNUAL GENERAL MEETING

NOTICE IS HEREBY GIVEN that the NINTH ANNUAL GENERAL MEETING of the BRITISH INTERPLANETARY SOCIETY will be held in the Kent Room, Caxton Hall, Caxton Street, London, S.W.1, on SATURDAY, **the 4th day of December, 1954,** at 6 o'clock in the evening precisely, for the transaction of the business specified in the Agenda below.

AGENDA

1. Chairman's Address.
2. To receive the annual statement of accounts and balance sheet for the year ended September 30, 1954 and the auditor's report thereon.
3. To elect four Members of the Council of the Society. In accordance with the provisions of Article 15, the following four Members of the Council will retire at that meeting, and, with the exception of Mr. W. N. Neat, offer themselves for re-election:

   D. J. Cashmore. J. Humphries. W. N. Neat. L. R. Shepherd.

   The following additional names have also been nominated:—

   J. A. Moyse *Fellow*. J. Simpson *Fellow*. H. P. Wilkins *Fellow*.

   Since the number of nominations exceeds the number of vacancies, election will be by postal ballot. The necessary ballot papers are enclosed with this agenda.
4. General discussion of the affairs of the Society during the past year.
5. Any other business.
6. Following the conclusion of the main business of the meeting, it is hoped to feature a short film show of newsreel pictures and other items of general interest.

By order of the Council,

L. J. CARTER,

Secretary.

A member who cannot be personally present at the meeting may appoint by proxy some other person (who must be a member of the Society) to attend and vote on his behalf, subject, however, to the limitation that a proxy cannot vote except on a poll.

ADDRESSES DELIVERED TO THE LONDON MEETINGS OF THE SOCIETY DURING THE SESSION 1953-1954

Saturday, August 29, 1953.

"Rockets and the Upper Atmosphere," by Dr. H. E. Newell.

This paper discussed the results of the information obtained by High Altitude Rocket Research on the Sun's radiation, the Atmospheric Structure of the F-region and primary cosmic rays. A summary of this paper appeared in January, 1954 *Journal*.

Saturday, October 3, 1953.

"A Programme for Achieving Interplanetary Flight," by A. V. Cleaver, F.R.Ae.S.

This paper dealt with the various phases of research and development which need to be covered before interplanetary flight can be achieved, with reference to the outstanding technical problems demanding solution and the probable means by which answers to them will be obtained in practice. The financial and organizational requirements of the final phases were dealt with in some detail in an attempt to suggest a practical plan for their realization.

It was printed in the January, 1954 *Journal*.

Saturday, November 7, 1953.

"Navigation Without Gravity," by J. G. Porter, Ph.D., B.Sc., F.R.A.S.

This paper considered how small errors in initial speed and direction cause large errors in the size and shape of the orbit, and described simple methods of navigation in space.

It was printed in the March, 1954 *Journal*.

Saturday, December 5, 1953.

"Annual General Meeting."

Details of the Proceedings at this meeting appeared in the November, 1953 and March, 1954 *Journals*.

Saturday, December 12, 1953.

"A Review of the Current Techniques of Protecting and Cooling Rocket Motor Walls," by H. Ziebland, A.M.I.Mech.E., Dipl.Ing.

The conventional techniques were described and their relative merits and limitations discussed, with particular reference to the problems of high pressure combustion of bi-propellant systems.

It was printed in the May, 1954 *Journal*.

Saturday, January 2, 1954.

"Possible Cosmic-Radiation Hazards in Space Flight," by L. R. Shepherd, Ph.D., B.Sc.

A brief review of our present knowledge regarding the nature of cosmic-rays and an evaluation of interplanetary vehicles.

Saturday, February 6, 1954.

"Progress Towards Astronautics," by K. W. Gatland.

A survey of recent developments in such fields as guided-missiles, high altitude sounding, supersonic aerodynamics, and aero-medical research.

It was printed in the May, 1954 *Journal*.

Saturday, March 6, 1954.

"The Design of a Life Compartment Necessary for Space Travel," by N. R. Nicoll.

An outline of the requirements necessary to sustain life during extra-terrestrial journeys, with an indication of how they may be met.

It was printed in the September, 1954 *Journal*.

Saturday, April 3, 1954.

"Film Show."

Two meetings were held at the Science Museum on this date, at 10.30 a.m. and 6.00 p.m. respectively. The morning show featured the film "Rocket Flight," while the evening show included the following:—

(*a*) *The Viking Rocket.*
(*b*) *High Altitude Research.*
(*c*) *Rocket Assembling and Launching.*
(*d*) *Rocket Instrumentation.*
(*e*) *Several newsreel releases.*

SYLLABUS OF ACTIVITIES OF THE MIDLANDS BRANCH DURING THE SESSION 1953-1954

Saturday, October 10, 1953.
"Space Vehicles," by D. A. Parish.
A review of the problems and engineering difficulties inherent in the development of vehicles for extreme altitude research, and an explanation of the fundamental steps leading to the development of a vehicle for space-flight. Particular reference was made to the feasibility study being carried out by the author and other members of the Midlands Branch.

Saturday, November 7, 1953.
"A Programme for Achieving Interplanetary Flight," by A. V. Cleaver, F.R.Ae.S.
This paper was previously read to the Society at a London meeting on October 3, 1953, and was printed in the January, 1954 *Journal*.

Saturday December 12, 1953.
"The Moon," by E. J. Burdon.
An illustrated talk giving a general description of the Moon, and a detailed description of some of the formations—craters of various types, maria, valleys, mountain ranges, clefts, etc.—concluded with an account of some of the controversial features.

Saturday January 16, 1954.
"Brains Trust." A Panel consisting of Messrs. W. Fielding, D. F. Lawden, M.A., and D. A. Parish, under the chairmanship of N. R. Nicoll, answered questions on various aspects of astronautics. Many questions were answered concerning various relativity effects, and there were lively exchanges between the panel and the audience.

Saturday, February 13, 1954.
"Astronautical Physics," by N. H. Langton, Ph.D.
This paper showed the use of physics in dealing with astronautical problems, and an example was given in the form of an investigation into the practicability of "bumper screens" as a defence against small meteors. The investigations showed that the screen would be effective within certain limits.

Saturday March 13, 1954.
"The Establishment of the Lunar Base," by R. A. Smith.
This talk dealt with the method of effecting a landing on the Moon, the growth of the temporary base into a permanent settlement, and the prospects of a self-supporting colony.

Saturday, April 10, 1954.
"Film Show."
At this meeting the following films were shown:—
(*a*) *The Bell X–5 Research Aircraft.*
(*b*) *Rocket Assembling and Launching.*
(*c*) *Experiments with Mammals in an Aerobee Rochet.*
(*d*) *The Viking Rocket.*
(*e*) *The Earth from a Rocket Mounted Camera.*

SYLLABUS OF ACTIVITIES OF THE NORTH-WESTERN BRANCH DURING THE SESSION 1953-1954

Saturday, September 19, 1953.
"Space Travel in Fact and Fiction," by A. C. Clarke, B.Sc., F.R.A.S.
A brief survey of the more important works in this field of literature, extending now over some eighteen centuries, with special reference to the means of transport proposed.

Saturday October 17, 1953.
"Interplanetary Fallacies," by H. E. Ross.
Where does Earth's gravitational field end? When does weightlessness begin? What is the temperature in space? These and other questions were discussed and corrections were made to some misconceptions of physical phenomena, impracticabilities and over-simplifications.

Saturday, November 21, 1953.
"Space Vehicles," by D. A. Parish.
A review of the problems and engineering difficulties inherent in the development of vehicles for extreme altitude research. The paper dealt with fundamental steps leading to the development of a vehicle for space-flight.

Saturday, January 9, 1954.
"Our First Goal—The Moon," by P. A. Moore, F.R.A.S.
An outline of how our knowledge of the Moon grew, the "seas," mountains and craters, followed by a description of the formation of these surface features and a discussion of the possibility that an atmosphere and life may exist.

Saturday, February 20, 1954.
"Building the Lunar Base," by R. A. Smith.
The lecture was concerned with the method of effecting a landing on the Moon, the growth of a temporary base into a permanent colony and the prospects of it being self-supporting.

Saturday, March 20, 1954.
(*a*) "Welding Under Vacuum Conditions," by P. L. Sowerby, A.M.C.T.
An outline of difficulties of fabrication which may be encountered during the erection of structures in the satellite orbit or on the Moon.
(*b*) "Solar Spectroscopy at Extreme Altitudes," by Eric Burgess, F.R.A.S.
An account of the methods used for recording the solar spectrum above the main absorbing layers of the atmosphere. Discussion of the results obtained.

Saturday, April 24, 1954.
Film Show which included the following astronomical and rocket films.
(*a*) *Rotation of the Planet Jupiter.*
(*b*) *Explosions on the Sun.*
(*c*) *Experiments with Mammals in an Aerobee Rocket.*
(*d*) *Views of the Earth from a V–2 Rocket.*
(*e*) *High Altitude Research.*
(*f*) *The Viking Rocket.*

SYLLABUS OF ACTIVITIES OF THE INFORMAL SCOTTISH BRANCH DURING THE SESSION 1953-1954

Sunday, January 17, 1954.
Formation of Branch. A lecture on the history and aims of the Society was given by Mr. Carter, who had flown up from London for the purpose, at the conclusion of which it was decided to form the Branch, and a Committee and Office Bearers were elected.

Thursday, February 25, 1954.
"Das Marsprojekt," by A. E. Roy, B.Sc., F.R.A.S.
An outline of Dr. Wernher von Braun's scheme for an expedition to Mars, followed by a discussion on the future development of astronautics.

Thursday, March 18, 1954.
"Film Show."
The films "*The German A–4 Rocket*," "*Rocket Instrumentation*," and "*High Altitude Research*" were shown.
A repeat performance of the three films shown in Glasgow the previous evening was given in Edinburgh on Friday, March 19, 1954.

Tuesday, April 27, 1954.
"Brains Trust."
A "Trust" of four members sitting under the chairmanship of Mr. J. R. R. Burton answered questions on astronautics raised by members of the audience.
The Annual General Meeting of the Branch was held at the conclusion of the proceedings.

SYLLABUS OF ACTIVITIES OF THE PROVISIONAL YORKSHIRE BRANCH DURING THE SESSION 1953-1954

Saturday, September 12, 1953 (*at Leeds*).
"Interplanetary Flight," by N. H. Langton, Ph.D.
A survey of the elementary principles of space-flight.

Saturday, October 17, 1953 (*at Leeds*).
"Mars," by P. A. Moore, F.R.A.S.
A review of the physical conditions of the planet and various theories put forward to account for the observed data.

Saturday, November 14, 1953 (*at Sheffield*).
"Civil Engineering on Other Worlds," by M. S. Wright, B.Eng.
An outline of some of the problems involved in setting up a permanent or semi-permanent base on some of the planets and satellites in the solar system.

Saturday, December 12, 1953 (*at Leeds*).
"The Moon," by M. C. Metcalfe.
A description of our satellite.

Saturday, February 13, 1954 (*at Sheffield*).
"An Account of Some Experimental Work on Rocket Fuels," by D. N. Hunter.
A description of a series of tests on various fuels carried out by the author, together with a summary of his results and conclusions, and an outline of future research.

Saturday, March 13, 1954 (*at Leeds*).
"Space-Flight—A Step in Life's History in the Universe," by H. S. Peiser, M.A.
A survey of man's place in the universe showing that future progress depends upon the conquest of space.

Saturday, April 10, 1954 (*at Sheffield*).
"Life on Other Worlds," by G. Hollis.
A description of the bases of and conditions for the appearance of Life, and the possibilities of finding intelligent beings on other planets.

SYLLABUS OF ACTIVITIES OF THE PROVISIONAL WESTERN BRANCH DURING THE SESSION 1953-1954

Saturday, September 26, 1953.
"The Exploration of Space," by A. C. Clarke, B.Sc., F.R.A.S. An outline of the history of the subject from man's first desire to conquer space to the latest developments.

Saturday, October 24, 1953.
"Pathway to Space," by S. W. Greenwood, M.Eng. An explanation of various methods for obtaining data on the Earth's atmosphere and theoretical studies applied to the data collected. The effect of the upper atmosphere on artificial satellites was considered.

Saturday, November 28, 1953.
"Forum in the Venusian Probe," conducted by F. Smith. Venus was selected as the subject as, owing to the opaque atmosphere, a "probing" mission was essential. Various design studies for the probe were put forward including designs for telemetering equipment and automatic control systems.

Saturday, January 23rd, 1954.
"The Development of Astronautics in the next 25 years," by E. Burgess, F.R.A.S. A review of current proposals and an outline of the paths along which these proposals may develop in the near future.

Saturday, February 27, 1954.
'Provisioning of Interplanetary Vehicles," by G. L. Garthwaite. This dealt with methods of food and atmosphere control and of photosynthesis of waste products to establish a closed cycle for a period of time.

Saturday, March 27, 1954.
"An Engineer's Criticisms of Some Space Flight Proposals," by F. R. Forbes Taylor. A practical criticism of engineering practice and methods of current designs and ideas for interplanetary vehicles.

Saturday, April 24, 1954.
"Film Show and Exhibition." Many models and photographs showed the historical development of the modern rocket and some possible future developments.

JOURNAL BINDINGS

Arrangements have been made with our printers for binding the *Journal* at a cost of 8s. (post free). The volumes are in dark green, with gilt lettering. Earlier volumes may also be bound in the same manner.

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The British Interplanetary Society

Limited (by Guarantee)

INCOME AND EXPENDITURE ACCOUNT for the year ended 30th September, 1954.

1953	*Expenditure.*	£ s. d.	£ s. d.
£			
	To Office and Management Expenses—		
219	Rent, Light, Heat, Cleaning and Insurance	232 13 11	
348	Salaries and National Insurance	416 6 3	
275	Printing and Stationery ..	272 3 4	
354	Postage, Telegrams and Telephone	245 4 10	
122	Publicity and Advertising ..	94 6 9	
109	Travelling and Entertaining Expenses	181 17 4	
—	Audit Fee	12 12 0	
119	Sundry Expenses	102 9 11	
1,546			1,557 14 4
2,363	,, **Publications**		2,168 3 4
217	,, **Expenses of Meetings** ..		293 8 11
	,, **21st Anniversary Celebrations—**		
—	Reserve and Expenses		380 9 7
	,, **International Astronautical Federation—**		
163	Contribution and Expenses ..		159 8 7
—	Income Tax		20 19 6
	,, **Depreciation and Amounts written off—**		
282	Furniture and Equipment ..	95 6 9	
112	Library	222 18 2	
			318 4 11
200	,, **Transfer to General Reserve**		300 0 0
	,, **Excess of Income over Expenditure** for year carried to		
458	Accumulated Fund		639 0 9
5,341			5,837 9 11

1953	*Income.*	£ s. d.	£ s. d.
£			
	By Membership Subscriptions and		
4,531	**Entrance Fees**		4,921 14 11
296	,, **Donations**		296 17 2
	,, **Library Subscriptions and Sale of**		
399	**Journals**		389 17 2
	,, **Income from Investments:—**		
	3½% Defence Bonds ..	18 5 4	
	,, Deposit Account Interest	28 10 6	
			46 15 10
115	,, **Sundry Receipts**		182 4 10
5,341			5,837 9 11

BALANCE SHEET as at 30th September, 1954.

1953	*Capital and Reserves.*	£ s. d.	£ s. d.
	Accumulated Fund—		
1,001	Balance at September 30, 1953 ..	1,459 10 0	
	Add Excess of Income over Expenditure for year to September 30, 1954	639 0 9	
458			2,098 10 9
1,459			
	Compounded Subscriptions		
1,035	**Reserve Account**		1,245 0 0
700	**General Reserve**		1,000 0 0
—	**Income Tax Reserve**	28 19 0	
—	**21st Anniversary Celebrations**	350 0 0	378 19 0
3,194	Total of Capital and Reserves		4,722 9 9
	Current Liabilities		
167	**Subscriptions Paid in Advance**	162 18 1	
207	**Sundry Creditors**	93 1 0	
			255 19 1

Certified to be a true copy—

L. R. SHEPHERD, G. V. E. THOMPSON } *Members of the Council.*

L. J. CARTER, *Secretary.*

3,568			4,978 8 10

1954	*Fixed Assets*	£ s. d.	£ s. d.
	Furniture and Equipment—		
923	At Cost	1,049 5 0	
323	*Less* Depreciation	419 5 0	
600			630 0 0
	Library—		
502	At Cost	572 18 2	
52	*Less* items written off	150 0 0	
450		422 18 2	
250	*Less* Depreciation	322 18 2	
200			100 0 0
	Investments—		
	Establishment Fund Deposit		
1,100	Account	2,000 0 0	
—	3½ per cent. Defence Bonds (P.O. Issue)	1,000 0 0	3,000 0 0
1,900	Total of Fixed Assets ..		3,730 0 0
	Current Assets		
51	**Sundry Debtors**	24 5 0	
92	**Payments made in Advance** ..	53 0 0	
1,491	**Cash at Bank Current Account**	1,154 11 9	
34	**Cash in Hand**	16 12 1	
			1,248 8 10
3,568			4,978 8 10

REPORT OF THE AUDITOR TO THE MEMBERS OF THE BRITISH INTERPLANETARY SOCIETY

I have obtained all the information and explanations which to the best of my knowledge and belief were necessary for the purposes of my audit. In my opinion proper books of account have been kept by the Society so far as appears from my examination of those books. I have examined the above Balance Sheet and annexed Income and Expenditure Account which are in agreement with the books of account. In my opinion and to the best of my information and according to the explanations given to me, the said accounts give the information required by the Companies Act, 1948, in the manner so required, and the Balance Sheet gives a true and fair view of the state of the Society's affairs as at 30th September, 1954, and the Income and Expenditure Account gives a true and fair view of the surplus of income over expenditure for the year ended on that date.

35, Brian Avenue,
Sanderstead, Surrey.

9th November, 1954.

T. W. WOODS,
Incorporated Accountant.

NINTH ANNUAL GENERAL MEETING

(For the convenience of members unable to be present, the Chairman's speech is reproduced below.)

CHAIRMAN'S ADDRESS

Gentlemen,

The year 1954 is a very special one in the history of our Society. It marks the coming of age of the B.I.S., which was founded in October, 1933. The anniversary has been commemorated by celebration dinners in London and in the various branches. Appropriately, our founder, Mr. P. E. Cleator, has figured as the guest of honour at several of these gatherings.

Our 21st anniversary seems to be an appropriate occasion for taking stock of the Society's growth, purpose and present position. We have come a long way since that rather remote date in 1933 when Phil Cleator first formed the Society. From a mere handful of members (in 1939 when the Society went into cold storage for the duration of the war there were only about 130 members) we have grown in number to nearly 2,600 and our activities have expanded from small homely gatherings, often in private houses or the back room of a public house, into frequent large public meetings held here in Caxton Hall and in various branch centres. Last year there were no less than 41 public meetings, including lectures by scientists and engineers in the Society, as well as a number of distinguished visitors. Public interest in the Society has grown enormously, and many leading scientific and engineering institutions have shown their own interest in astronautics by inviting members of the B.I.S. to deliver lectures.

Perhaps the most striking aspect of the expansion of the Society lies in the publication field. From 1934 to 1939, twelve issues of the *Journal* were published containing a total of 188 pages. Last year the *Journal*, together with the membership list, ran to 392 pages, very nearly double the complete pre-war output. Apart from this striking increase in quantity we believe that we have produced a steady improvement in quality, both in the technical and popular side of our publication.

With the growth of the Society we have seen a change in the conception of the proper role of the B.I.S. To a great extent this change in outlook, as well as the striking pre-war expansion, has been the result of events outside the Society. I refer to the enormous strides made in the development of rocket propulsion and other fields relevant to astronautics. When the B.I.S. was first formed the example of the German V.f.R. was in the minds of our pioneer members, and experimentation on rockets was deemed to be the desirable aim of the Society. It turned out that funds for experimentation, even on the humble scale of the early German enthusiasts, were not forthcoming, and the main preoccupation of the active members immediately before the war centred on the design study of a lunar rocket, which many of us now refer to, sentimentally, as the "B.I.S. Spaceship."

When, in 1945, the B.I.S. was reformed it soon became apparent that the days of small scale experimentation belonged to the past. The development of interplanetary flight was obviously destined to be a gradual and costly business

calling for the resources of government sponsored agencies. The immediate role of the B.I.S. seemed to lie in the stimulation both of popular and technical interest in astronautics, in the initiation of individual and group studies of many of the scientific and engineering aspects of astronautics and in the publication of both popular and technical literature relating to space flight. Our progress in the pursuit of these objectives gives us some grounds for satisfaction, though we should certainly not become complacent about our success. I believe that we have still much ground to cover in carrying out this initial programme. At the same time we may well be reaching a stage where a more active role for the B.I.S. might be possible. In the event of the formation of a high altitude rocket research panel in this country, for example, we should certainly hope for some B.I.S. representation. I feel that we should lose no opportunity of advancing scientific interest in the instrument-carrying satellite rocket, which, after all, must be the first real exercise in space flight. I would like to see some of our members who have the necessary time, qualifications and enthusiasm, take this matter up with serious scientific studies into the feasibility of using such a device as an instrument for research into Supra-atmospheric phenomena. In addition, we ought to think seriously about stimulating individual research in Universities and similar institutions into some of the more fundamental or long term problems of astronautics.

While we are on the subject of active B.I.S. participation in the development of astronautics, we should not forget the fact that many of our members are professionally occupied with the development of rocketry. It is fairly well known in this Society that the rocket propulsion groups of two of the leading aircraft manufacturers in this country are rather heavily loaded with B.I.S. members. We should always keep in mind the desirability of establishing the B.I.S. as a recognized professional Society in the engineering and scientific fields relevant to astronautics.

To conclude my remarks on the development of the B.I.S. over its first twenty-one years, I would like to remind the members of the fact that this development has not been accidental. Certain members of the Society have had to devote a great amount of time and energy to promoting the interests of the B.I.S. We have been particularly fortunate in having such an active and enthusiastic Secretary as Mr. Carter. The post-war expansion of the B.I.S. has been due, in no small measure, to his efficiency and business acumen.

Looking to the future, I am a little disturbed to find that, here, in the headquarters area, there does not seem to be a stream of younger enthusiasts coming forward to replace the older pioneering members in the advancement of our Society. I have gained the impression that active interest in B.I.S. affairs is becoming more marked in the Branches than in London. It may well be that younger people are discouraged from coming forward owing to the present size and scale of activity of the Society. Certainly, it is far easier to feel and exercise a pioneering spirit in a small group than in a large organization. Whatever the cause, I hope that this scarcity of new blood in the active ranks of the B.I.S. will prove to be a purely temporary one. It would be a great pity if the expansion of our organisation during its first twenty-one years were not matched by a proportionate development during the next twenty-one years.

The Present Year

Turning now to the affairs of the Society during the 1953–1954 session. I am happy to report a continued expansion in membership and activities and a steady, though not spectacular, improvement in our financial position.

Membership

The current membership of the Society as of 30th September, 1954 is 2,588, i.e., 1,947 members, 635 fellows and 6 honorary fellows. It is interesting to compare this figure with those for the corresponding dates of previous years since the war. These are summarized in the following table.

Date	*Fellows*	*Members*	*Total*
1946	79	190	269
1947	151	293	444
1948	148	354	502
1949	183	394	577
1950	245	680	925
1951	358	1,130	1,488
1952	489	1,521	2,010
1953	584	1,835	2,419

It will be seen from these figures that the rate of increase in the membership has shown a marked decline during the past year. The number of new members joining the Society during the past session has been 600 compared with 746 in the previous session. On the other hand the number of members not renewing their subscriptions has increased to 450 this year compared with 337 in the previous year.

The secretary has issued a comprehensive survey of membership statistics and a further analysis of the figures has been made by Mr. D. J. Cashmore. These surveys reveal that many members joining the Society drop out after a few years. The decline (with passing years) of any given batch of members joining the B.I.S. can be described by fairly simple mathematical laws.

Fellows stay in the Society on a much more permanent basis, for, whereas, half of the ordinary members fall out after about four years, in the same period only about 30 per cent. of Fellows fall out. Of course, no firm prediction can be made on the number of members who will join the Society in the course of any session. This depends upon fluctuation of interest in astronautics, advertising campaigns and other factors, many of which are outside the control of our organisation. However, if this year's intake could be maintained, Mr. Cashmore's analysis seems to indicate that the membership of the B.I.S. would eventually flatten out at about 6,000.

Meetings

With five branches now in being, or in formation, the number of meetings conducted by the B.I.S. has increased considerably. During the past sessions the number of meetings in the different branches and at Headquarters have been as follows:

London (including the A.G.M.)	9
Manchester	7
Birmingham..	7
Bristol (Informal Branch)	7
Leeds/Sheffield (Informal Branch)	7
Glasgow (Informal Branch)	4

The expansion of activities of the branches is a particularly encouraging feature in the development of the Society during the past two or three years. It is a sign of active interest, which is vital to the future progress of the B.I.S. The Branch Officers are to be commended for the industry which they have displayed in organising the local programmes.

Publications

Perhaps the most important single activity of the B.I.S. is the publication of its journal. During the past year progress in this respect has been maintained and six issues of the *Journal* have appeared. The *Journal* continues to be edited by our indefatigable Secretary. There has been one change in the Publications Committee, Mr. D. F. Lawden replacing Mr. A. C. Clarke as a full time member, though Mr. Clarke continues to help in the work of this committee when he is in the country.

It is, perhaps, appropriate at this point to put in a plea on behalf of our editor. During the past few months there has been a serious fall-away in *Journal* material, and Mr. Carter has been put to a great deal of worry and extra work in soliciting last-minute articles in order to fill the gaps. It is most important that we should receive high quality technical papers and good papers of popular interest in a steady supply. In the past we have always succeeded in bringing out the Journals on time, thanks mainly to the hard work of the editor and the helpful co-operation of Messrs. Heffer & Sons. The steady expansion in size of the *Journal* is making this task increasingly difficult and it is particularly important, therefore, that all those members who have something original to contribute and feel qualified to do so, should set pen to paper and help to sustain the steady progress of our publication. Of course, I have to emphasise, as a member of the Publications Committee, that we do expect the papers accepted for publication to conform to a fairly high standard and while making a plea for more material we do not intend to lower our standards in order to fill the pages of the *Journal*.

Turning to the lesser, though by no means unimportant publishing activities, we have issued further copies of the Book Lists (12th, 13th and 14th printings) and a second set of postcards, illustrating modern rockets is now available. On the lighter side the B.I.S. Christmas Card, which has proved so popular in the past, is likely to be retained in future years provided that suitable illustrations are available. Unfortunately, owing to pressure of other work, it has not been found possible to issue a Christmas card for the current year in time.

One of our more successful enterprises has been the film strip on Space Flight. Already, 300 copies of this have been sold and we are anxious to issue more.

During the year we have continued to distribute the bi-monthly journal of the American Rocket Society, to those of our Fellows who require it. It is regretted that we do not receive a sufficient number of these to issue copies to all Fellows. We regret, also, the fact that during the past year two issues were lost in transit from America to Messrs. Heffer & Sons, who handle the distribution.

It is perhaps appropriate before closing these remarks on publication activities, to draw attention to the fact that during the past year the Acta Astronautica Committee of the I.A.F., on which I had the honour of representing the B.I.S., completed its plans for publishing the *Acta*. This journal, which will carry purely technical material, is to be published by Springer of Vienna, commencing in the new year. The cost will be rather high, about £3 10s. per volume, but there will be a reduction, probably of twenty per cent., for members of the various societies of the I.A.F. Subscriptions to the *Acta Astronautica*, must be made through the B.I.S. if the reduced rate is to apply. I hope that, despite the high price, we shall have a good response from our members. Full details of these arrangements will appear in the *Journal* when they are completed.

Finance

The accounts for the financial year ending 30th September, 1954, appear on pages 370-371.

During the year we have been able to transfer £300 to the Subscription Reserve Account, which we have now renamed "General Reserve Account," making a total to date of £1,000.

The cost of publications shows a slight decline compared with that for last year, since the latter included the List of Members, but this is compensated by a reserve of £350 made in the current year to cover the cost of the Society's 21st Anniversary Celebrations.

Reserves from compounded subscriptions continue to rise. At present 48 members and fellows have taken advantage of the scheme. To those members who prefer the alternative of paying an annual subscription, I would like to offer the suggestion that they pay through a Bankers Order. This method of payment greatly reduces the work at B.I.S. headquarters in handling cheques, issuing reminders, etc. A Bankers Order form is enclosed with this current issue of the *Journal*.

All our available savings have now been invested in 3½% Defence Bonds and a special Bank Deposit Account where they earn a small but useful interest. These funds are being retained separately to cover the eventual cost of the Society's own premises.

Council

During the Session, the Council has met on 12 occasions to conduct the affairs of the Society. At one of these meetings (November, 1953), following recent practice, the Chairmen and Secretaries of the Branch Committees were present when Branch affairs were under review. The Branch Secretaries also met under the chairmanship of the Society's Secretary to discuss problems relating to administration of the Branches. Such meetings will be held annually in the future.

In accordance with the constitution of the Society the following Members of the Council retire at the end of this year:

D. J. Cashmore	W. N. Neat
J. Humphries	L. R. Shepherd.

Mr. Cashmore was co-opted to serve in place of Mr. Ross who resigned because of ill health and automatically retires at the termination of Mr. Ross's period of office.

Three of the retiring members offer themselves for re-election, but Mr. W. N. Neat has indicated that, at the present time, he does not wish to stand for a further period in office. Some regret must be expressed at this decision in view of the able and conscientious service which he has given during his three years on the Council. However, I would like to extend to Mr. Neat, on behalf of the Society, our thanks for his co-operation, with the wish that at a later election he might come forward again as a candidate for the Council.

At the time of the last A.G.M. we learned with some regret that a serious illness had forced Mr. Ross to withdraw from the Council. I am now happy to report that Mr. Ross has made an excellent recovery and I hope that we shall see him actively engaged once again in our organization.

Concluding Remarks

It has been a particular honour for me to have served as Chairman of the Council during this significant year in the life of our Society. This has been a year of improvement and consolidation with the B.I.S. established as a well organized society of modest size. Although the rapid rise in membership seems to be coming to an end, the hard core of members with a lasting interest in astronautics must be increasing steadily, with consequent increase in the stability of the Society. We may look forward to the fact that even if our actual numbers do not show much further increase during the coming years, they will at least tend to become a truer measure of the size and strength of the Society.

Finally, I would like to remind all members of the rather special circumstances of our Society. These arise from the fact that the field in which we function is one whose development lies largely in the future. Because of this preoccupation with a subject which is necessarily speculative and uncertain, we have a task that is somewhat more difficult than that of the average professional society. We must be an active organisation, alert to all possible opportunities for advancing astronautics. Our aim must be to build up a Society consisting mainly of members who individually or in groups, in the course of their professional activities or their activities within the B.I.S., are engaged in advancing the development of space flight. The preliminary successes of the Society have been encouraging but still leave a great deal to be done before we are functioning as we should do.

It remains for me to express my thanks to all those who have given their time and effort to the work of the B.I.S. during the past year and my hope that their number will be augmented considerably during the coming year.

L. R. SHEPHERD,
Chairman of the Council.

List of Donations

Donations totalling £296 17s. 2d. were received from 474 members during the year and are gratefully acknowledged.

A list of the donors of amounts of 10s. and over is printed below:—

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